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NIAGARA '86
AIR QUALITY SURVEY REPORT

(Occidental Chemical Corporation)
Niagara Falls, New York, USA)

POLYCHLORINATED BIPHENYL (PCB)
INCINERATION TEST
NOVEMBER 1986

ARB-048-87-AQM

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Ontario
Ministry
of the
Environment

E. PICHÉ, Director
Air Resources Branch

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(Occidental Chemical Corporation
Niagara Falls, New York, USA)

Polychlorinated Biphenyl (PCB) Incineration Test

November 1986

ARB - 048 - 87 - AQM

Prepared for:

Niagara River Improvement Programme
Intergovernmental Relations and Strategic Projects Division
Ministry of the Environment

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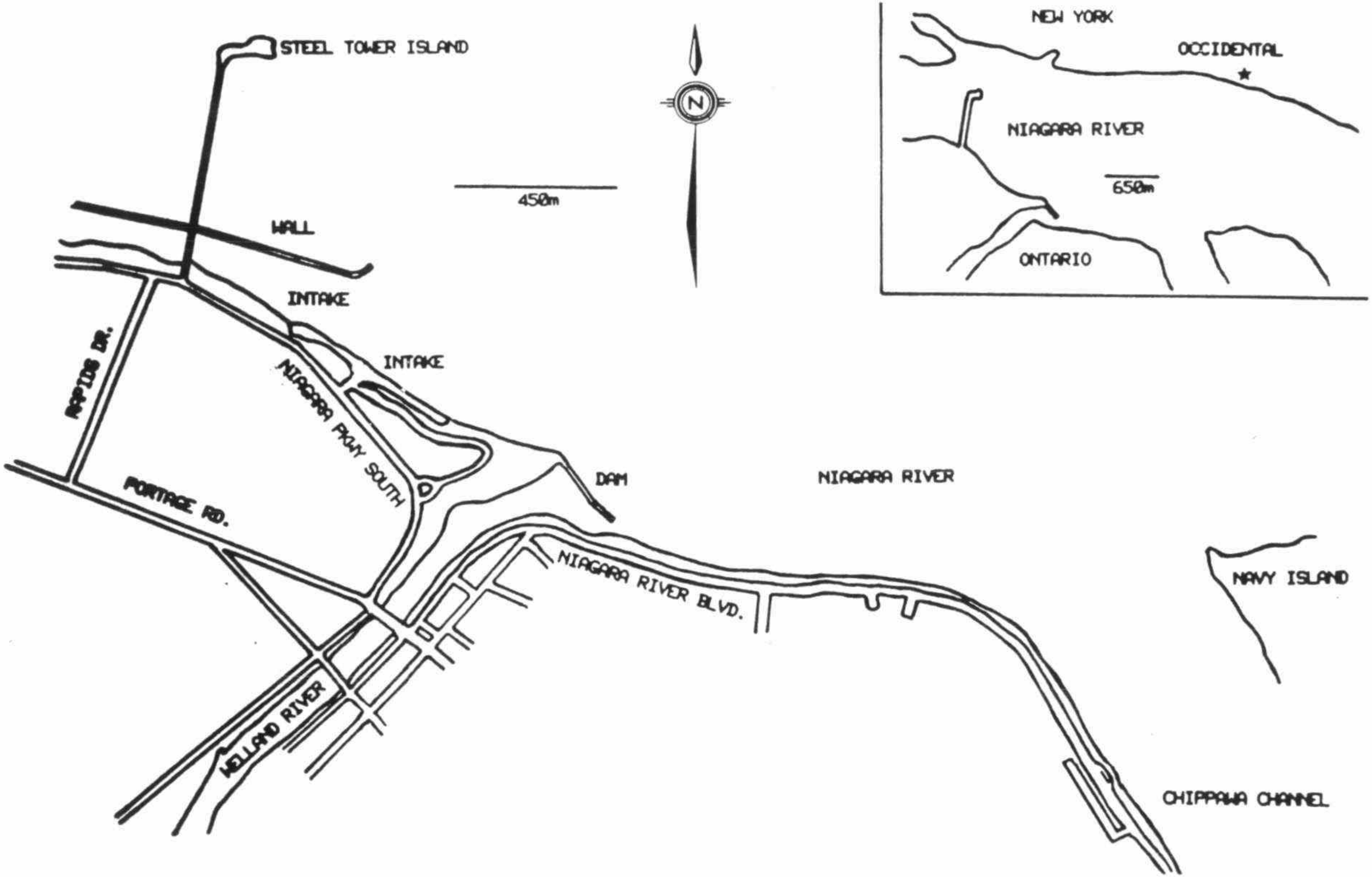
General Survey Area for the '86 Niagara Survey



EXECUTIVE SUMMARY

At the request of the Ministry's Niagara River Improvement Programme, Mobile Air Monitoring Units (MAMu's) #1 and #3 of the Air Resources Branch conducted an ambient air survey in the Niagara Falls area of Ontario during November 1986. The overall survey objectives were to provide on-site and real-time screening of the ambient air for selected PCB (polychlorinated biphenyl) congeners (MAMu#3 and the TAGA - Trace Atmospheric Gas Analyzer mass spectrometer system); for other organic hydrocarbons (MAMu#1 and the GC - Gas Chromatographic system); and to keep accurate recordings of the prevailing winds during the PCB incinerator tests taking place at Occidental Chemical Corporation in Niagara Falls, New York.

All sampling locations were along the Canadian side of the Niagara River and approximately 2.5 to 3 kilometres (km) south of the Occidental incinerator. Monitoring commenced on November 3; the PCB feed started at noon on November 5; and the entire survey ended on November 10 when the PCB incineration was completed at Occidental.

Regardless of the wind directions encountered during this survey, no PCBs were detected during this monitoring programme. In other words, all ambient air concentration measurements for PCBs made by the TAGA mass spectrometer were below its analytical detection limits - i.e. below 0.04 $\mu g/m^3$ for total (di- to penta- chlorobiphenyls) PCBs. The Ministry Guideline for allowable concentration levels of PCBs in ambient air is 0.45 $\mu g/m^3$.

With respect to the other compounds monitored during this survey, all results were indicative of a relatively clean urban environment. Most importantly, even when the winds were proper and monitoring was conducted downwind of Occidental during the times of PCB incineration, no applicable Environmental Regulations were exceeded or even approached for any of these other identified and confirmed compounds.

RÉSUMÉ

En réponse à la demande des responsables du Programme d'amélioration de la rivière Niagara (programme du ministère), les unités mobiles d'analyse de l'air (MAMU) n^{os} 1 et 3 de la Direction des ressources atmosphériques ont effectué une étude de l'air ambiant dans la région de Niagara Falls, en Ontario, au cours du mois de novembre 1986. Cette étude avait pour objet d'analyser l'air ambiant sur place et en temps réel afin de déterminer la présence de certains BPC (biphényles polychlorés) (analyse effectuée par l'unité MAMU n^{o} 3 et par le spectromètre de masse de l'unité mobile d'analyse de gaz à l'état de trace dans l'atmosphère (TAGA)), et d'autres hydrocarbures organiques (analyse effectuée par l'unité MAMU n^{o} 1 et au moyen de l'appareil de chromatographie en phase gazeuse); cette étude avait également pour objet de noter avec précision les vents dominants lors des essais d'incinération des BPC faits à l'Occidental Chemical Corporation à Niagara Falls, dans l'État de New York.

Tous les échantillons d'air ont été prélevés sur la rive canadienne de la rivière Niagara, de 2,5 à 3 kilomètres (km) au sud de l'incinérateur de l'Occidental. L'étude a commencé le 3 novembre; l'incinération des BPC a débuté le 5 à midi et l'étude a pris fin le 10 novembre, lorsque l'Occidental a terminé l'incinération.

Indépendamment de la direction du vent, aucune trace de BPC n'a été relevée au cours de l'étude. En d'autres termes, toutes les mesures de concentrations de BPC dans l'air ambiant effectuées par le spectromètre de masse de l'unité TAGA étaient inférieures au seuil de détection de l'appareil, c'est-à-dire à 0,04 $\mu g/m^3$ pour les BPC totaux (des biphényles dichlorés aux biphényles pentachlorés). La concentration maximale de BPC dans l'air ambiant permise par le ministère est de 0,45 $\mu g/m^3$.

En ce qui a trait aux autres composés dont on a mesuré la concentration lors de l'étude, tous les résultats indiquent que le milieu urbain est relativement sain. Ce qu'il importe de souligner, c'est que même dans le cas des échantillons prélevés sous le vent de l'Occidental au moment de l'incinération des BPC, les concentrations de ces composés identifiés étaient bien en deçà des limites prescrites par les règlements environnementaux.

1.0 Introduction

For two weeks in November 1986, Mobile Air Monitoring Units (MAMUs) #1 and #3 of the Ministry's Air Resources Branch performed an air monitoring survey in the Niagara Falls area of Ontario. This survey had several objectives: **firstly and most important,** MAMu#3 was to provide near real-time measurements of volatile polychlorinated biphenyls (PCBs) through the utilization of the TAGA (Trace Atmospheric Gas Analyzer) mass spectrometer system; **secondly,** MAMu#1 was to provide on-site measurements of other organic compounds (including other chlorinated species) through the utilization of a dual capillary column high resolution gas chromatographic (GC) system; and **thirdly,** MAMu#1 was to make accurate readings of the prevailing winds - both at the surface and aloft through the use of the on-board meteorological station and the release of upper air minisondes. These three objectives were to be carried out during the PCB destruction tests conducted by Occidental Chemical Corporation in Niagara Falls, New York, U.S.A.

Currently, the TAGA/ASTA (Trace Atmospheric Gas Analyzer with an Automated Short Term Adsorber) unit is the only method available to the Ontario Ministry of the Environment by which the ambient air can be scanned for PCBs in near real-time and thus provide the pertinent air quality data on site necessary for immediately assessing the environmental impact from this PCB destruction process.

During this same period, the instrumentation of MAMu#1 also provided real-time and on-site ambient air concentrations for over 130 different organic compounds, 8 to 10 common contaminants and a complete set of ground-based meteorological parameters. The investigation of wind dynamics aloft and the delineation of any inversion layer(s), especially in the lower 2 km, was accomplished through the release of minisondes and tracking by automated dual theodolites which were also interfaced with MAMu#1.

Thus, in the unlikely event that airborne PCBs from Occidental Chemical Corporation were impinging on Ontario, this monitoring programme would provide a safeguard for the residents of Niagara Falls, Ontario.

This survey commenced on November 3; the PCB feed started at noon on November 5; and the entire survey ended on November 10 when the PCB incineration was completed at Occidental. All sampling locations were in Ontario, adjacent to the Niagara River and upstream of the Falls (see Figure 1). This report describes and summarizes the monitoring results obtained by both monitoring units during this 1986 Niagara Falls survey.

2.0 Technologies and Survey Strategies

2.1 MAMu#3 and the TAGA System

A detailed description of the PCB monitoring technique is provided in Appendix A. Briefly, the TAGA (model 3000) is a specialized single quadrupole mass spectrometer with an atmospheric pressure, chemical ionization (APCI) source. When monitoring PCBs, the TAGA ion source is directly coupled to a computer controlled PCB preconcentrator and thermal desorption device called an Automated Short Term Adsorber (ASTA).

The TAGA/ASTA technique provides ambient PCB measurements in 2-minute intervals. The half-hour average concentrations are computed by averaging 15 consecutive 2-minute samples. In this study, the PCB congeners targeted were the di-, tri-, tetra- and pentachlorobiphenyls.

Calibrations of the TAGA/ASTA for gaseous PCBs were performed at least twice daily. Detection limits were typically 0.01 $\mu g/m^3$ per congener or 0.04 $\mu g/m^3$ for total (di- to penta-chlorobiphenyls) PCBs. The relative standard deviations for multiple injections of known PCB standards were generally better than 5% at the 0.425 $\mu g/m^3$ level.

The survey strategy was to position MAMu#3 along the Ontario side of the Niagara River, opposite Occidental's incinerator and acquire PCB measurements during the testing episodes. Prior to the start of the PCB destruction tests, the TAGA was calibrated for PCB detection and background data was acquired for a period of at least 30 minutes. This background data was used to correct the downwind measurements.

2.2 MAMu#1 and the GC System

Although the determination of ambient concentrations of PCBs by the TAGA mass spectrometer of MAMu#3 was the most important facet of this survey, the environmental data acquired by MAMu#1 was deemed necessary to support the measurements obtained by this mass spectrometer system.

In particular, the gas chromatographic (GC) system of MAMu#1 had the capabilities of identifying and quantitating over 130 different organic compounds at a detection level of 1 to 10 µg/m³ (micrograms per cubic metre) and being more specific, several of the more important and common chlorinated hydrocarbons (alkanes, alkenes and aromatics). (See Table #1 in Appendix C.)

This GC system was calibrated every day through the injection of a known n-alkane mixture of C_3 to C_{12}. The new retention times were acquired and the retention index library was updated. Prior to active monitoring of any selected source, a background sample was always acquired and subsequently analyzed. This data would be used for background or upwind subtraction from any downwind data acquired pertaining to a particular source.

The other instrumentation of MAMu#1 continuously measured a wide variety of common contaminants (see Table #2) and were calibrated daily through the use of on-board permeation tube sources, compressed gases and other electrical/chemical validation techniques. The response of the Total Hydrocarbon (THC) analyzer and the wind monitoring station of MAMu#1 were closely monitored and when the winds were proper and an increase was displayed by the THC analyzer, a GC sample was usually acquired.

The survey strategy closely followed that of MAMu#3 since both units were deemed to be complementary and a single source was under investigation. It should be stressed that in lieu of general air quality monitoring, single source, point of impingement monitoring was undertaken whenever and wherever feasible with respect to Occidental Chemical Corporation such that all acquired ambient air data would adhere to the applicable Environmental Regulations.

2.3 Meteorological Data

Wind dynamics were very important during this survey. Any gaseous emissions from Occidental Chemical would be transported or carried into

Canada if and only if the winds were from the northnorthwest to east-northeast quadrant. Wind direction outside this range would mean that emissions from Occidental would have to travel considerable distances (i.e. greater than 10 km) before they would impinge on Canadian territory.

In order to maintain a comprehensive record of the relevant wind dynamics, both MAMu#1 and #3 continuously recorded a wide variety of ground-based meteorological parameters (including wind speed and direction, ambient temperature, humidity, barometric pressure and solar radiation).

To supplement these ground-based measurements and to investigate and maintain a record of the winds and temperature aloft (up to a height of 1 to 2 km), upper air minisondes were released daily,. The release of these minisondes and the subsequent data acquisition was handled by a stand-alone system or co-ordinated through the acquisition system of MAMu #1. Since each minisonde was tracked by a dual theodolite system separated by as much as 2.5 km, very accurate triangulations of exact minisonde positions were achieved, resulting in very good measurements of wind direction and speed aloft.

2.4 Sampling Locations

Most sampling was conducted at the second intake site, referred to as Site A in all maps, southsouthwest of Occidental. Both monitoring units obtained shore-line electrical power at this site and as a result, MAMu#1 was able to monitor (unmanned) for the gaseous common contaminants and meteorological parameters overnight and during the weekend.

Otherwise, the monitoring units were capable of mobile sampling, obtaining electrical power from on-board generators and moving to locations directly downwind of Occidental.

3.0 Discussion of Data Acquired by MAMu#3 (TAGA/ASTA System)

Active air sampling and analysis for PCBs were conducted on November 5, 6, 7, 8 and 10 using the Ministry's TAGA mass spectrometer system. Since the winds were from the south or west during most of these monitoring periods, the monitoring locations were usually upwind of Occidental Chemical Corporation of New York State. (See Figure 1 of Appendix B.)

3.1 November 5

The winds were moderate (5 to 30 km/hr) and out of the southeast all day. The mobile TAGA unit was on shore-line power at the 2nd Intake site (A) and this site was therefore upwind of Occidental. Between 10:30 and 19:30 hrs, 13 half-hour (averaged) air samples were screened for PCBs and none were detected above the detection limits of 0.04 μg/m^3 for total (di to pentachlorobiphenyls) PCBs. Given the wind direction, these results were considered as being background samples.

3.2 November 6

Apparently, PCBs were not introduced into the incinerator at any time during this day. In case the incinerator status changed, the TAGA was placed on stand-by and the crew remained at Site A until 18:00 hours. During this stand-by time, two half-hour (averaged) air samples were screened for concentrations of the selected PCBs to confirm the TAGA's system operating functions.

3.3 November 7

During the morning, the winds were too light and variable to determine a true wind direction at Site A. Nevertheless, PCB monitoring was conducted between 10:00 and 12:30 hrs and as shown in Table 3 of Appendix B, PCBs were not detected.

At about 13:30 hrs, MAMu#3 moved to Site B which was on the Niagara River Boulevard, approximately 3 km east of Site A and directly opposite Navy Island. Finally, albeit for a brief period, the conditions were excellent for air monitoring: first, the winds were northerly and steady at 10 to 15 km/hr; second, the sampling location was the closest possible to and directly downwind from Occidental Chemical Corporation without having to leave Ontario; and third, PCBs were being incinerated. Despite these desired conditions, PCBs were not detected at this site (specifically between 13:53 and 14:25 hrs) and after 14:30, the winds started shifting easterly. The TAGA crew attempted to find another sampling location, but had no success. The PCB burn operation ceased at 15:00 hrs.

3.4 November 8

Since the winds were southerly at 10 to 25 km/hr, specific source monitoring of Occidental could not be undertaken on this date. Thus, after background monitoring and calibrations were completed at Site A, the TAGA was placed on stand-by for the duration of the incinerator tests (to approximately 14:00 hrs) carried out on this date.

3.5 November 10

Once again, the winds were carrying Occidental's emission away from Ontario and the preselected monitoring locations. Two background air samples were analyzed for PCBs (see Table 5). The survey was halted at approximately 15:00 hrs when the stack sampling and incineration tests were completed at Occidental.

4.0 Discussion of Meteorological Conditions and other Data as Acquired by MAMu#1 (G.C., Common Contaminant and Minisonde Systems)

4.1 November 3

A low pressure area was centered just south of Lake Superior and a warm front extended southeastward over Lake Michigan on this date. The air mass in southern Ontario was becoming moist and unstable with moderate (10 to 20 km/hr) southwesterly winds forecasted. The winds were expected to veer overnight and become northwesterly by tomorrow morning as this frontal system pushed into southern Ontario.

MAMu#1 arrived at Site A on the Niagara River (the 2nd Intake) in the early afternoon. The surface winds were light and variable. All instrumentation within MAMu#1 was calibrated and the necessary arrangements were made to set up for overnight monitoring. As usual for overnight monitoring, only the continuous analyzers were in operation (i.e. the common contaminants) and monitoring commenced at 16:00 hrs. The results were general air quality data since no specific source could be ascertained. Nevertheless, from this overnight data, the concentrations were indicative of a rural environment and no applicable Environmental Air Quality Criteria were exceeded or approached. (Refer to Table #3 of Appendix C.)

4.2 November 4

The centre of this low pressure area had tracked to the Hudson Bay area. The warm front had pushed through southwestern Ontario and now this area was under the influence of a cold frontal system. Because of the pressure gradient associated with this frontal system, the winds were significant (35 to 40 km/hr) and easterly. **No PCB incineration was taking place at Occidental on this day.** Thus this day was reserved for background measurements and once again, rechecking and recalibrating all instruments housed in MAMu#1.

One GC sample was acquired at this site and a very light total hydrocarbon loading was measured (19 different organics were identified and the total loading was only 20 µg/m³ (micrograms per cubic metre) - refer to Table #4 of Appendix C). Just before noon, the common contaminant analyzers were fully calibrated and long-term or overnight monitoring commenced. Again, background concentration levels were recorded for these common contaminants and no applicable Environmental Air Quality Criterion was exceeded or approached.

4.3 **November 5**

After the passage of the aforementioned cold front, a high pressure area dominated the weather over Ontario on this date. The air mass in southern Ontario was moist yet stable and the winds were light to moderate southeasterly.

Because of the prevailing southeasterly wind pattern, MAMu#1 continued monitoring at Site A until 14:30 hrs. In addition to the common contaminant data, three one-hour GC samples were also acquired during this time. From these results, all hydrocarbon loadings were very light (only 11 to 30 different organics were identified from the GC samples and the total loadings were only 25 to 30 µg/m³); no applicable Environmental Regulation was exceeded or approached; and the results were again deemed to be indicative of a rural environment.

Since the winds still displayed a southeast tendency during the early afternoon, MAMu#1 moved to downtown Niagara. It was hoped that this new location would be downwind of the industrial area located on the American side of the Niagara River and thus also be downwind of Occidental. MAMu#1 finally set up on Kitchener Street in the Niagara Central arena parking lot and commenced acquiring data at 15:00 hrs. The winds were well defined at this time and were southeast and moderate at 10 to 30 km/hr. As can be seen by the resultant wind and pollution rose (Total Hydrocarbon data), this site was still not downwind of this industrial area. This information was forwarded to MAMu#3 (the TAGA Unit) and thus they remained at the permanent site (A) and acquired background data. Nevertheless, over 4 hours of common contaminant data and 3 one-hour GC samples were acquired at this downtown site by MAMu#1. The resultant data was now indicative of a relatively clean urban environment. Forty to 48 different organics were detected in the GC samples and the total hydrocarbon loadings were again very light (an average of 121 $\mu g/m^3$) with the dominant fractional group being alkanes (81 $\mu g/m^3$ or 67% of the total loading). Thus this was indicative of home heating effects and to a certain extent, some vehicular exhaust emissions. The common contaminant data support this statement and once again, no applicable Environmental Criteria were exceeded for any of the measurements.

After 19:00 hrs, MAMu#1 returned to Site A at the 2nd Intake where it was prepared for overnight monitoring of the common contaminants. This monitoring commenced at approximately 21:00 hrs and from the acquired data, all concentrations were low and no Environmental Regulations were approached or exceeded.

4.4 November 6

The effects of the high pressure area still persisted over southern Ontario on this date. The air mass was still moist and stable but now the winds were from the southsouthwest and reasonably light (less than 10 km/hr). Because of these winds, the emissions from Occidental were being transported northward into the States.

Since the 2nd Intake monitoring site was definitely upwind of Occidental, this day was reserved for calibrating and rechecking all the analyzers of MAMu#1 and for gaining operational experience with the dual theodolite upper air minisonde system.

The locations of the theodolite sites and the minisonde release site are shown in Map #1 of Appendix D. Six minisonde flights were conducted during the early afternoon and as can be seen from the resulting upper air data (Plot #1 of Appendix D), a frontal inversion was noted at a height of approximately 800 metres. Since the surface winds were moderate (up to 30 km/hr) and southerly below this inversion and were moderate and westerly (veering) above, this was a classic example of a warm frontal inversion layer aloft. This was very important meteorological data since it clearly shows that the ground level emissions from the industrial site on the American side of the Niagara River would be trapped below this inversion layer and would be carried northward over the States. It also shows that a warm front was approaching the Niagara area; overcast strata type clouds were to be expected and that the winds behind this front would be westnorth-westerly and moderate.

Just before 18:00 hrs, overnight monitoring of the common contaminants commenced. At this time and for the remainder of the survey, only the meteorological parameters and the total hydrocarbon data were monitored on a continuous basis by the instrumentation (apart from the GC) of MAMu#1. From this overnight monitoring, an enhancement of the total hydrocarbon ground level concentrations was noted (up to a maximum of 3.86 ppm (parts per million) for a one-hour average) in the early morning as the frontal system pushed through this area. An increase in ambient temperature and a continual veering of the winds (albeit very light(usually less than 5 km/hr)) to the east and southeast was also noted during this time.

4.5 November 7

The Niagara area was in the warm sector of the low pressure area that was now centred just north of Ottawa at 7:00 a.m. The air mass was moist and yet somewhat stable (broken stratocumulus) and the winds were very light during the morning. The overnight monitoring continued until 13:00 hrs and as mentioned earlier, the results were somewhat elevated but were generally indicative of an urban environment. At just before 13:00 hrs, a one-hour GC sample was also acquired and again the results were indicative of a relatively calm urban environment (the total hydrocarbon loading was only 89 $\mu g/m^3$ and the alkane fraction comprised over 78% of this total).

Since the surface winds were light and highly variable and the PCB feed at Occidental was not to take place before 10:30 am, interest was then directed to the dual theodolite and minisonde system for on-site prognosis of winds. At 12:25, the first minisonde of the day was released. The results clearly showed that the winds below 700 metres were northerly and very light (less than 2 km/hr) and that above this height, the winds abruptly shifted to the south and increased in speeds up to 30 or even 40 km/hr. As mentioned earlier, any monitoring to be done on the Canadian side of the Niagara River would mean a minimal source (the Occidental Incinerator) receptor (MAMu#1) distance of 2 to 3 km. If the PCB feed started on time and if the plume from Occidental was buoyant (it was not; it was a very wet plume as noted by ARB's on-site observer, Mr. G. Wong), this minisonde data clearly showed that it would still take an additional one to three hours for the emissions from this incinerator to be carried across to the Canadian side of the Niagara River.

Owing to these facts and the realization that the surface winds had become more prominent and were northnortheasterly at 13:00 hrs, MAMu#1 moved from Site A to #8373 East Service Road (Site B) which was due south of the industrial area on the American side of the Niagara River and more importantly, directly downwind of Occidental.

Commencing at 13:49 hrs, over two hours of common contaminant data and two half-hour GC samples were acquired at this downwind site. From this data, slight increases in the continuous measurement of ground level concentrations of total hydrocarbons (up to 2.6 ppm for a one-hour average) and in the total hydrocarbon loadings as derived from the GC samples (an average total loading of 123 $\mu g/m^3$) were noted. Once again, no applicable Environmental Regulations were exceeded by any of these organics and the resulting data were indicative of a reasonably clean urban environment. The data acquired at this site was very similar to the data acquired in downtown Niagara Falls on November 5 but in this case, the wind dynamics clearly pointed to the industrial area on the American side of the Niagara River as being the only possible source for these measurements. (See wind pollution rose for this data... Graph #2 in Appendix C.)

In order to keep an accurate record of the winds, additional minisonde launches were carried out during the afternoon on this date. From the data acquired during the 14:16 flight, the low level winds were still from the northeast and pronounced (now near 10 km/hr); from the 16:38 flight, the winds had moved more easterly and finally, from the 16:53 flight, the low level winds were due easterly and had increased in speed up to 15 km/hr. The monitoring crew was notified that the PCB feed was halted at Occidental around 15:00 and owing to the low level winds (especially the speed), monitoring was halted shortly after 16:30 hrs. Since the winds had shifted further to the east after this time, Site A was considered to be more or less downwind of the American industrial area. Thus MAMu#1 moved back to this site and was prepared for overnight and background (since the PCB feed was stopped at Occidental) monitoring. This monitoring was to continue until November 10, the last day of this survey.

4.6 November 8 to 10

The weak cold front associated with this low pressure area passed through southern Ontario during the night. By early Saturday morning, the winds were brisk (up to 20 km/hr for a one-hour average) and southerly. Moist and unstable weather conditions were present (scattered showers in the afternoon). PCBs were being incinerated at Occidental and the emissions were being carried northward over New York State.

No PCBs were being incinerated at Occidental on November 9; however, the meteorological conditions and the continuous monitoring of total hydrocarbon ground level concentrations continued at the 2nd Intake site.

Another low pressure area was pushing into the Niagara area from the Central States on Monday, November 10. Cold westerly winds up to

30 km/hr were present in this area and a few light snow flurries were expected. PCBs were being incinerated at Occidental on this date but the winds were again carrying these emissions into New York State. All monitoring was halted after 15:00 hrs, when the environment staff was informed that the PCB incineration process at Occidental was finished.

Moderate total hydrocarbon ground level concentrations (up to 3.1 ppm for a maximum one-hour average) were recorded during these last three days of monitoring at the 2nd Intake Site and the ground-based wind data supported all the observed emission directions for Occidental.

It is interesting to note that from the ground level total hydrocarbon data acquired at the 2nd Intake Site during the 166 hours of this survey, no one-hour average directional concentration exceeded 2.2 ppm and no well defined source of THC could be ascertained. As noted from the resulting pollution rose for this data, the measured THC was shown to be ubiquitous for this area. (Refer to Graph #3 in Appendix C.)

5.0 Acknowledgements

During these tests, Mr. G. Wong of ARB's Emission Technology and Regulation Development Section provided the crews of MAMu#1 and #3 with pertinent information regarding the operational status of the Occidental PCB destruction unit. Mr. C. Desson and Mr. N. Buonocore of the West-Central Region also assisted the crews of these monitoring units in the selection of the monitoring sites. Finally and most important, because of this close liaison, the West-Central Region of the Environment Ministry was always kept informed of the real-time PCB monitoring results.

6.0 Summary

All sampling locations were along the Canadian Side of the Niagara River and approximately 2.5 to 3 kilometres (km) south of the Occidental incinerator. Monitoring commenced on November 3; the PCB feed started on November 5; and the entire survey ended on November 10 when the PCB incineration was completed at Occidental.

Regardless of the wind directions encountered during this survey period, all ambient air concentration measurements for PCBs made by the TAGA/ASTA mass spectrometric unit were below the analytical detection limit of this unit - i.e. below 0.04 µg/m³ for total (di to penta-chlorobiphenyls) PCBs. The applicable Ministry Guideline for ambient air concentrations of PCBs is 0.45 µg/m³. Being more specific and due to the fact that the monitoring units had to remain on the Canadian side of the Niagara River, for approximately 35 hours that the mobile TAGA was on stand-by, only one 30-minute sample was acquired when the meteorological conditions were excellent for downwind single source PCB monitoring of emissions from Occidental. All ambient air monitoring for PCBs were based on half-hour averaged samples. Including background monitoring, 24 of these samples were acquired over this period and none of the selected PCBs were confirmed to be present in any of these samples.

With respect to the other organic compounds detected in ambient air by the gas chromatographic system of MAMu#1, all loadings were very light (all less than 150 µg/m³) and only 30 to 50 common organics were detected in any of the acquired GC samples. These organics were indicative of a relatively clean urban environment. Finally, but most important, even when the winds were proper and MAMu#1 was positioned downwind of Occidental, no applicable Environmental Regulations were exceeded or even approached for any of these identified and confirmed organic compounds.

For the other contaminants measured by the instrumentation of MAMu#1, all concentrations were very low and again, no applicable Environmental Regulations were exceeded.

APPENDIX A

Air Resources Branch

Mobile TAGA Technology and PCB Monitoring

Niagara Falls - November (1986)

TAGA TECHNOLOGY

In 1979 the Air Resources Branch of the Ontario Ministry of the Environment acquired a mobile Trace Atmospheric Gas Analyzer (TAGA) from Sciex Incorporated of Thornhill, Ontario. The mobile TAGA unit (MAMU No.3) has been applied to a variety of air monitoring situations, including airborne PCBs. The Ministry has conducted over 50 air quality surveys with the mobile TAGA unit.

The TAGA 3000 is a specialized quadrupole mass spectrometer coupled to a unique sampling inlet and ion source (See Figure A1). Ionization of pollutants is achieved through chemical ionization, initiated by a stable corona discharge operating at atmospheric pressure. Since the ion source permits continuous, direct, air sampling at a high flow rate (100 l/min), it is possible to determine the temporal and spatial distribution of selected pollutant levels. The mobile TAGA's capabilities are especially suitable for plume tracking; that is, tracing a pollutant back to its source of origin.

When equipped with the standard atmospheric-pressure chemical ionization (APCI) source the TAGA system is sensitive to most volatile compounds containing a heteroatom, such as N, O, S, P and halide. Typical detection limits are in the range of 0.1 to 10 ug/m^3 depending on the type of chemical measured and the sample matrix.

The mobile TAGA unit is also equipped with a 10 metre, telescopic tower and meteorological instrumentation to measure local wind speed, wind direction and ambient temperature. All meteorological data are stored by the on-board computer simultaneously with the collection of air quality data. The data are instantly displayed on the CRT unit allowing the operator to assess the data on-site and thus formulate the appropriate survey strategy.

PCB MONITORING METHODOLOGY

For most chemical classes the sensitivity of the TAGA is extraordinary for ambient air monitoring. However PCBs are an exception, because the absolute sensitivity is insufficient for instantaneous real-time detection. Thus in the late 1970s Sciex Inc. developed a simple sampling device to preconcentrate volatile PCBs. Preconcentrating the PCBs for only 2-minutes lowers the detection limit by two orders of magnitude.

ASTA

Although the basic principles have remained unchanged, today's PCB preconcentrator has evolved into a portable sampling inlet system with all operating parameters under strict computer control. It is commercially known as the Automated Short Term Adsorber or ASTA.

The ASTA, shown in Figure A2, consists of two sample probes formed by coiling a nichrome wire, coated with a gas chromatographic stationary phase, OV-17. The positions, and thus functions of the two probes, are interchangeable between the adsorption or sampling position, and the desorption or analysis position. While one probe is adsorbing PCBs from the ambient air, the other probe is being desorbed and analysed for PCBs from a previous air sample. Altering the positions of the two probes permits continuous screening of the ambient air in 2 minute intervals. There is approximately an eight second delay between sampling periods due to the probe cycling time. Thus a "½-hour sample", which consists of 15 consecutive 2 minute samples, takes 32 minutes.

Sampling

When sampling for PCBs the probe is placed directly in the ambient gas stream (1.7 l/s) for a period of 2 minutes. The probe is then changed to the desorb position and 12 volts DC (3.25 amperes) are applied to the probe for a period of 40 seconds. This causes the probe temperature to rapidly increase to approximately 300°C, thereby transferring the PCBs from the OV-17 into the gas phase. The carrier gas, which is a mixture of ultra pure zero air and benzene (100 ppm), constantly sweeps the PCBs into the ion source. Upon entering the ion source the PCBs immediately undergo benzene chemical ionization, producing molecular PCB ions (M^+) which are (mass) selectively monitored by the quadrupole mass filter.

The software allows for the screening of 4 PCB congeners at 8 masses, 2 isotopes per congener. Normally the dichlorobiphenyl to pentachlorobiphenyl species are monitored. There are two reasons for this: firstly, the TAGA is more sensitive to these species, and secondly, PCBs with lower molecular weights generally exhibit higher vapour pressures, thus increasing the likelihood of gas phase detection.

Calibration

Calibration of the system, including sampling probe adsorption efficiencies and TAGA response, is accomplished by continuously injecting known amounts of PCBs directly into the air sampling stream via a heated injection port (300°C) using a gas-tight syringe and motorized syringe drive. The PCB standards are prepared by the dissolution of pure PCB isomers, one per congener, into iso-octane. Repeated injections at 5 different syringe drive settings establishes a calibration curve which is linear (correlation coefficients are usually better than 0.995) over the PCB concentration range of 0.425 to 2.5 ug/m³ per congener (See Figure A3). The relative standard deviations for multiple injections of PCB standards are typically better than 5% at the 0.425 ug/m³ level.

DATA PROCESSING AND INTERPRETATION

Immediately following a desorption of the probe, the TAGA computer calculates the level of PCBs (or equivalents) per congener, per isotope, from the net signal (sample minus background) and the daily calibration factors. In fact, for each PCB congener group, two measurements are made: one for the chlorine 35 isotope (M), and one for the corresponding chlorine 37 isotope (M+2).

Criteria

At this stage the field survey scientist interprets the reduced data using the following criteria:

1) the adsorption peak (integrated signal) must be at least 3 times greater than the probe noise (S/N>3);

2) the PCB levels for a given isotope pair must be within the overall experimental accuracy of 20%;

3) the calculated isotope ratios must be within 10% of the theoretical isotope ratio for a given congener.

If condition 1) above is not satisfied, the congener concentration will be considered below the detection limit and a ND is reported. If conditions 2) and 3) are not evident then a chemical interference at one, or both, of the congener masses is assumed to be present, and the lower concentration value of the two isotopes is assigned the upper concentration limit for that particular PCB congener. The value is then flagged with the letter "i" indicating that a chemical interference has inflated the reported concentration. An example of a data print-out showing the PCB desorption curves may be seen in Figure A4.

Detection Limit

The PCB detection limit for the TAGA/ASTA technique is defined as being 3 times the standard deviation of the background signal observed at the PCB masses, divided by the appropriate calibration factors. Thus by definition, the detection limit depends on two important factors:

i) the sensitivity, which is a function of the probe adsorption efficiencies and the benzene chemical ionization rates.

ii) the level of the interferences (adsorbed compounds that have the same nominal ionic mass as the targeted PCBs in both upwind and downwind air samples). Interference levels are highly variable depending on the sampling site, the source(s) in the immediate area, and the local meteorological conditions.

During a survey air samples are spiked periodically with 0.425 ug/m^3 per PCB congener to establish the daily sensitivity factors and determine, on-site, the detection limits of the technique. Typical detection limits range from 0.01 to 0.05 ug/m^3 per congener, or from 0.04 to 0.20 ug/m^3 for total (di to pentachlorobiphenyls) PCBs, depending on the complexity of the sample matrix.

SUMMARY

The TAGA/ASTA PCB monitoring technique is a specialized application of the mobile TAGA 3000. It was developed to rapidly screen the ambient air for volatile PCBs. Important features of the technique to consider when assessing the data are:

1) The technique was developed to measure gas phase PCBs. (Should non-volatile PCBs be trapped by the probe they would be reported as volatile PCBs and included in the total amounts.)

2) PCB levels are determined continuously every 2 minutes.

3) Four congeners are monitored simultaneously (normally the dichlorobiphenyls to pentachlorobiphenyls).

4) The detection limits for total PCBs typically range from 0.04 to 0.20 ug/m^3 depending on the sample matrix.

In summation, the mobile TAGA/ASTA technique is a rapid screening method for volatile PCBs, providing near real-time detection at the time when PCBs are potentially released into the atmosphere. It is the only method currently available to the Ministry by which the ambient air can be instantaneously scanned for PCBs, providing valuable information, on-site, necessary for assessing the environmental impact of the PCB destruction process.

TAGA 3000 SYSTEM

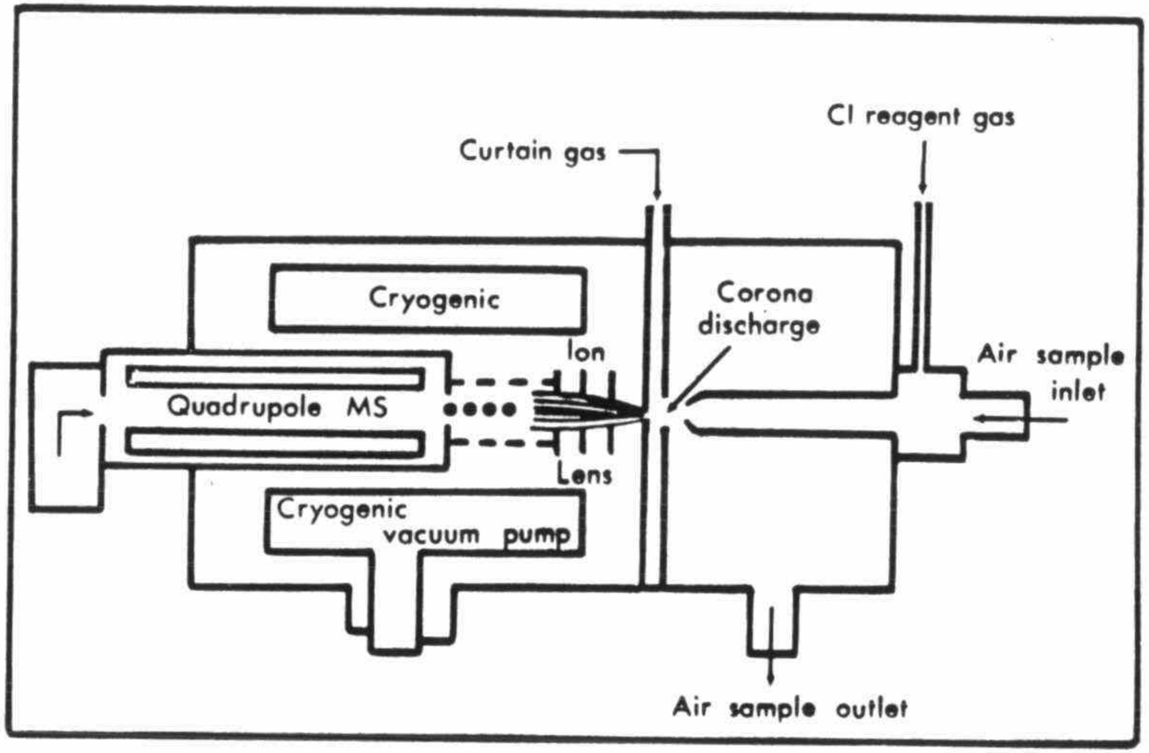


FIGURE A1: SCHEMATIC OF THE TAGA 3000 SYSTEM
INSTALLED IN MAMU #3

ASTA SCHEMATIC

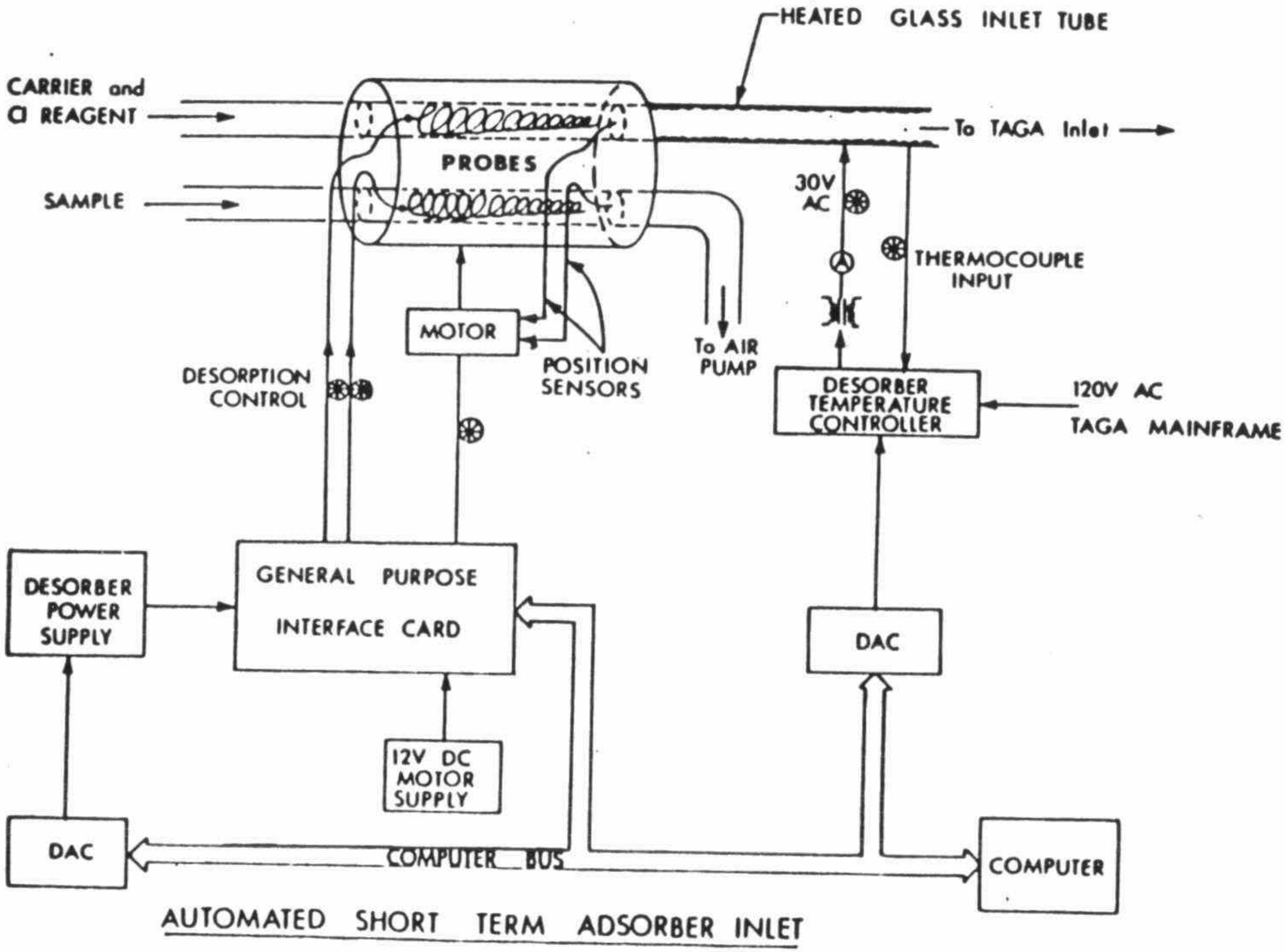


Figure A2: Schematic of the ASTA used in conjunction with the TAGA PCB Monitoring technique.

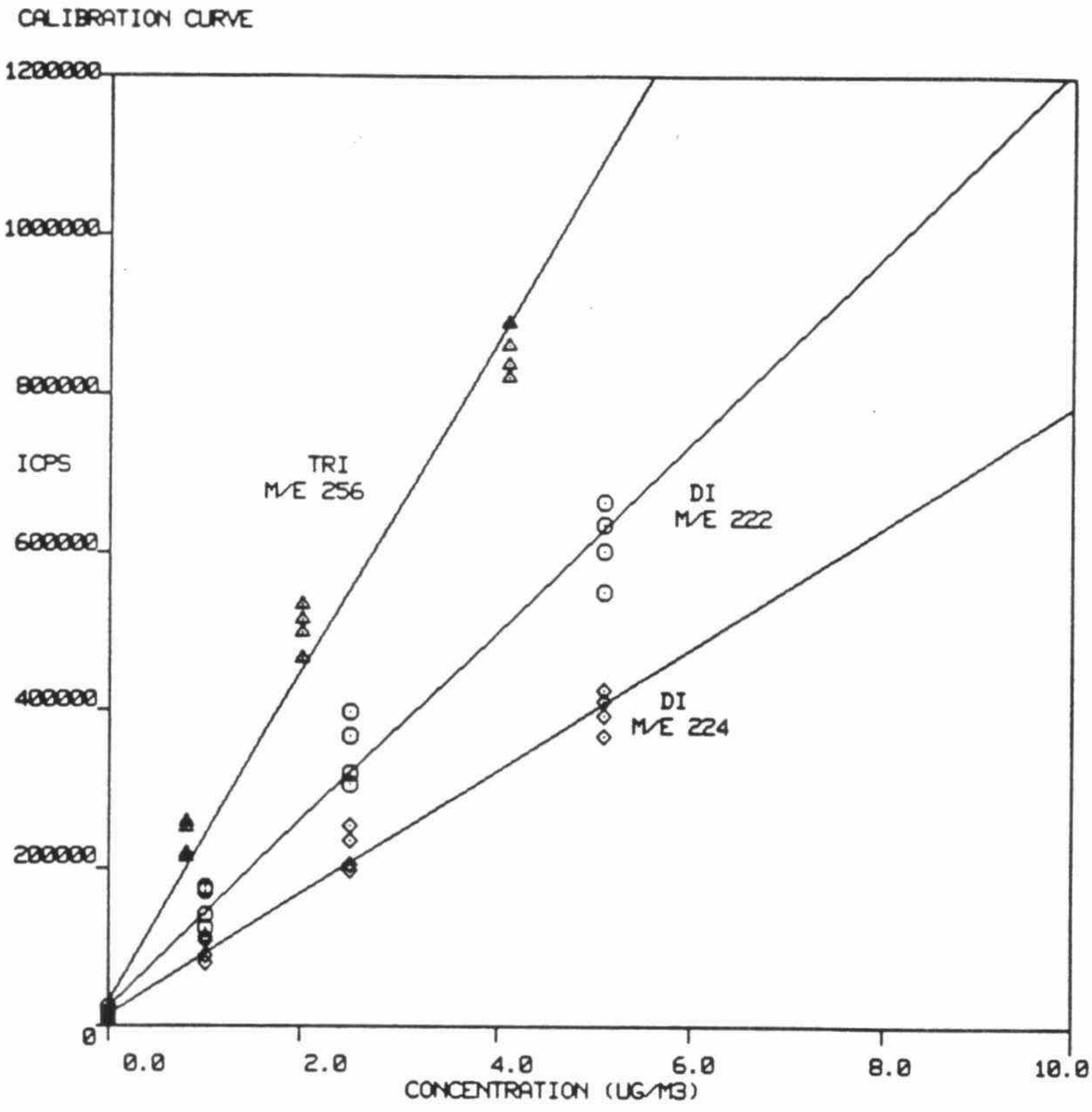
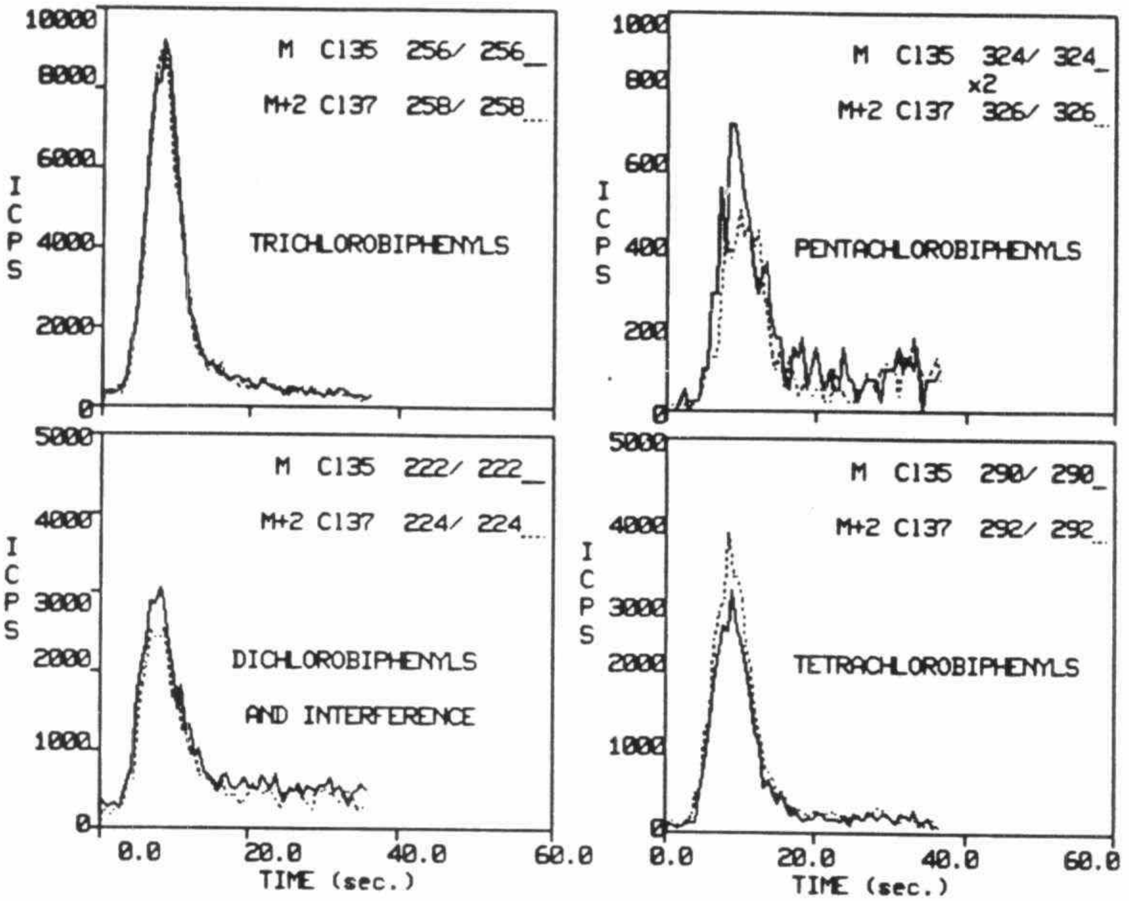


FIGURE A3: EXAMPLE OF CALIBRATION CURVE
FOR DI AND TRICHLOROBIPHENYLS

TAGA/ASTA MONITORING TECHNIQUE



MP/MD	MAX.INT	TIM.MAX	INT.IONS	NET	CONC	RATIO TO MP/MD		THEOR.
222/ 222	3053.	8.40	17143.	14691.	0.39i	1.283	224/ 224	1.540
224/ 224	2520.	9.12	13994.	11452.	0.47	0.780	222/ 222	0.650
256/ 256	9213.	8.56	46335.	43368.	0.60	1.056	258/ 258	1.030
258/ 258	8906.	8.64	43545.	41069.	0.62	0.947	256/ 256	0.975
290/ 290	3067.	9.36	14284.	12730.	0.23	0.818	292/ 292	0.769
292/ 292	3800.	8.80	17271.	15562.	0.23	1.222	290/ 290	1.300
324/ 324	360.	9.52	1707.	1303.	0.10	0.620	326/ 326	0.615
326/ 326	507.	10.24	2662.	2099.	0.11	1.612	324/ 324	1.626
					1.3i			

FIGURE A4: Example of TAGA data print-out, PCB analysis. Concentrations are in units of ug/m3. Note the ratio for isotope (222/224) dichlorobiphenyl is mismatched. Total PCB level is computed to be 1.3i ug/m3, where i denotes a contribution by interference at masses 222 and/or 224.

APPENDIX B

MAMu#3's (THE TAGA SYSTEM) RESULTS

Monitoring Sites for MAMu#3

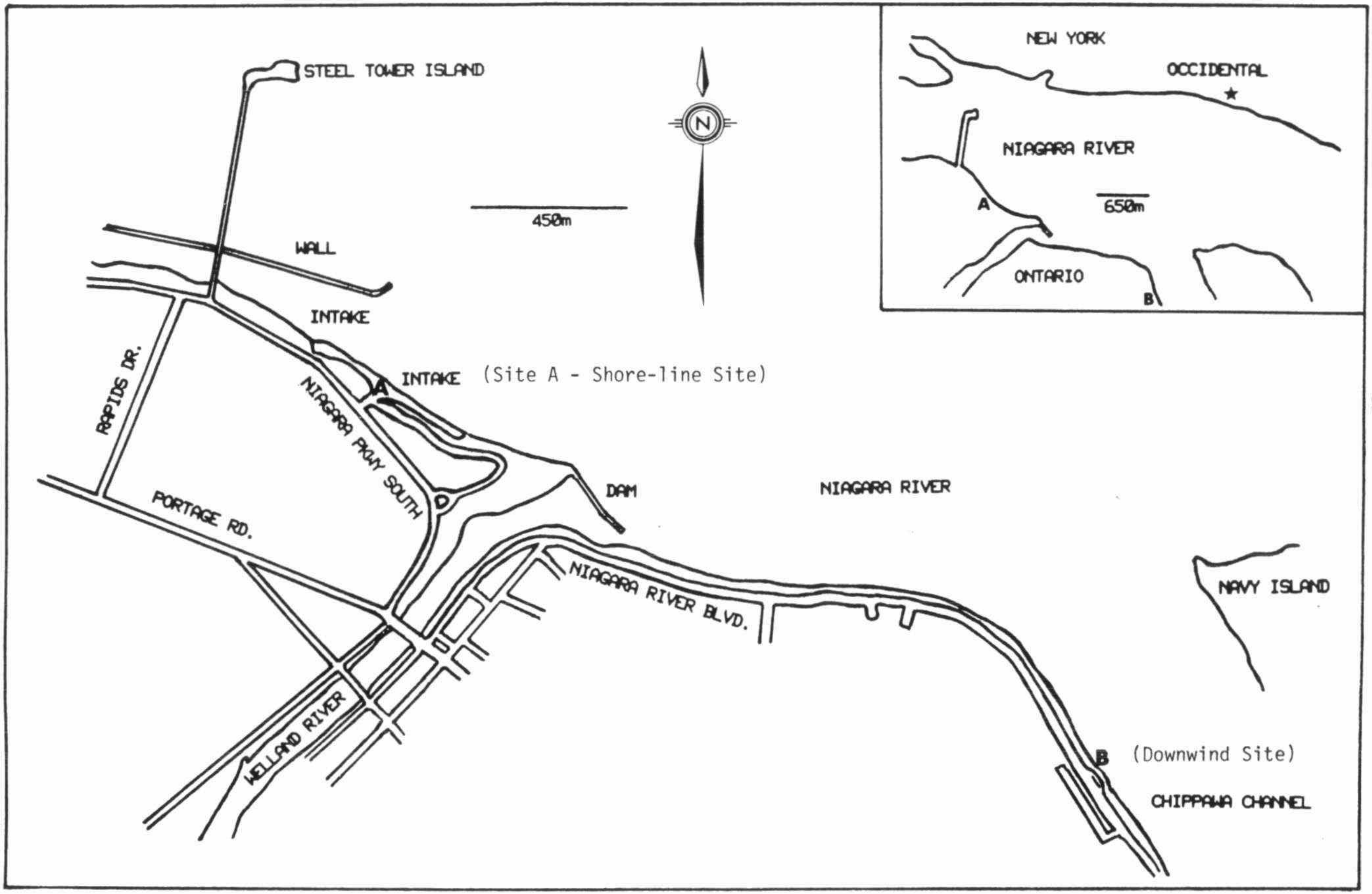


TABLE 1 TAGA PCB SURVEY : Niagara Falls, Ontario - November 5, 1986

SAMPLE #	SITE	TIME	METEOROLOGY AT	WD	WS	CONC. (μg/m³)	COMMENTS
1-1	A	10:32	3	SE	20-30	ND	UPWIND, background, no PCBs
1-2	A	11:04	3	SE	20-30	ND	UPWIND, background, no PCBs
1-3	A	11:48	4	SE	20-30	ND	UPWIND, background, no PCBs
1-4	A	12:20	4	SE	20-30	ND	UPWIND, background, PCBs introduced @ 12:30
1-5	A	13:27	5	SE	20-30	ND	UPWIND, background, PCBs burned
1-6	A	14:24	7	ESE	15-20	ND	UPWIND, background, PCBs burned
1-7	A	14:55	6	SE	5-15	ND	UPWIND, background, PCBs burned
1-8	A	15:27	6	SE	5-15	ND	UPWIND, background, PCBs burned
1-9	A	15:59	6	SE	5-15	ND	UPWIND, background, PCBs burned
1-10	A	16:31	6	SE	5-15	ND	UPWIND, background, PCBs burned
1-11	A	17:39	7	S	5-15	ND	UPWIND, background, PCBs burned
1-12	A	18:20	7	S	0-10	ND	UPWIND, background, no PCBs
1-13	A	18:52	7	S	0-10	ND	UPWIND, background, no PCBs

Note:

1. All monitoring periods are 30 minutes.
2. See Figure 1 for monitoring locations.
3. Time refers to the adsorb time of the first sample.
4. AT = Ambient Temperature (°C); WS = Range of Wind Speeds in km/hr; WD = Predominant Wind Direction.
5. ND = Not Detected above 0.04 μg/m³ for total of the di to pentachlorobiphenyl congeners.

TABLE 2 TAGA PCB SURVEY : Niagara Falls, Ontario - November 6, 1986

SAMPLE #	SITE	TIME	METEOROLOGY AT	WD	WS	CONC. (µg/m³)	COMMENTS
2-1	A	10:49	9	W	5-15	ND	UPWIND, background, not burning PCBs
2-2	A	11:21	11	W	5-15	ND	UPWIND, background, not burning PCBs

Note:

1. All monitoring periods are 30 minutes.
2. See Figure 1 for monitoring locations.
3. Time refers to the adsorb time of the first sample.
4. AT = Ambient Temperature (°C); WS = Range of Wind Speeds in km/hr;
   WD = Predominant Wind Direction.
5. ND = Not Detected above 0.04 µg/m³ for total of the di to pentachlorobiphenyl congeners.

T019.2

TABLE 3 **TAGA PCB SURVEY : Niagara Falls, Ontario - November 7, 1986**

SAMPLE #	SITE	TIME	METEOROLOGY			CONC. (µg/m³)	COMMENTS
			AT	WD	WS		
3-1	A	10:08	11	SE	0-5	ND	UPWIND?, PCBs burned
3-2	A	10:40	11	E	0-5	ND	UPWIND?, PCBs burned
3-3	A	11:20	12	ENE	0-5	ND	DOWNWIND?, wind speed too low, PCBs burned
3-4	A	12:00	12	N	0-2	ND	NIL WIND SPEED, PCBs burned
3-5	B	13:53	10	N	10-15	ND	DOWNWIND, PCBs burned

Note:

1. All monitoring periods are 30 minutes.

2. See Figure 1 for monitoring locations.

3. Time refers to the adsorb time of the first sample.

4. AT = Ambient Temperature (°C); WS = Range of Wind Speeds in km/hr;
   WD = Predominant Wind Direction.

5. ND = Not Detected above 0.04 µg/m³ for total of the di to pentachlorobiphenyl congeners.

TABLE 4 TAGA PCB SURVEY : Niagara Falls, Ontario - November 8, 1986

SAMPLE #	SITE	TIME	METEOROLOGY			CONC.	COMMENTS
			AT	WD	WS	($\mu g/m^3$)	
4-1	A	10:32	14	SSE	10-25	ND	UPWIND, background, PCBs burned
4-2	A	11:10	13	SSE	5-20	ND	UPWIND, background, PCBs burned

Note:

1. All monitoring periods are 30 minutes.
2. See Figure 1 for monitoring locations.
3. Time refers to the adsorb time of the first sample.
4. AT = Ambient Temperature (°C); WS = Range of Wind Speeds in km/hr;
   WD = Predominant Wind Direction.
5. ND = Not Detected above 0.04 $\mu g/m^3$ for total of the di to pentachlorobiphenyl congeners.

T019.4

TABLE 5 TAGA PCB SURVEY : Niagara Falls, Ontario - November 10, 1986

SAMPLE #	SITE	TIME	METEOROLOGY			CONC. ($\mu g/m^3$)	COMMENTS
			AT	WD	WS		
5-1	A	10:36	1	WSW	15-25	ND	UPWIND, background, PCBs burned
5-2	A	11:08	2	W	10-25	ND	UPWIND, background, PCBs burned

Note:

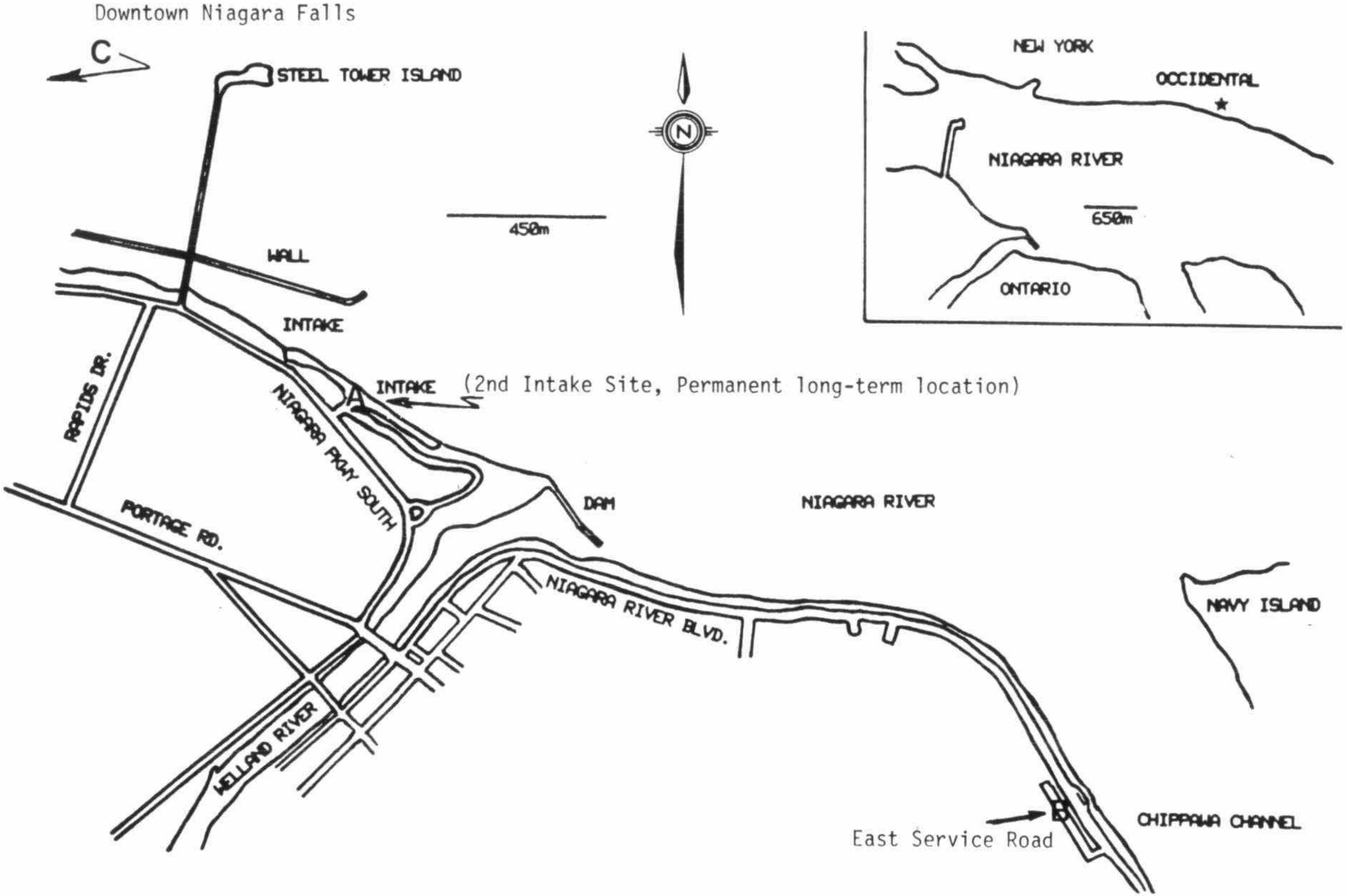
1. All monitoring periods are 30 minutes.
2. See Figure 1 for monitoring locations.
3. Time refers to the adsorb time of the first sample.
4. AT = Ambient Temperature (°C); WS = Range of Wind Speeds in km/hr;
   WD = Predominant Wind Direction.
5. ND = Not Detected above 0.04 $\mu g/m^3$ for total of the di to pentachlorobiphenyl congeners.

T019.5

APPENDIX C

MAMu#1's (COMMON CONTAMINANT & GC SYSTEMS) RESULTS

Monitoring Sites for MAMu#1



Downtown Niagara Falls

(2nd Intake Site, Permanent long-term location)

East Service Road

TABLE #1

CHEMICAL COMPOUND LIST FOR MOBILE AIR MONITORING UNIT #1

ALKANES

ETHANE
PROPANE
2-METHYLPROPANE
BUTANE
2-METHYLBUTANE
PENTANE
2,2-DIMETHYLBUTANE
2,3-DIMETHYLBUTANE
2-METHYLPENTANE
3-METHYLPENTANE
HEXANE
2-METHYLHEXANE
2,3-DIMETHYLPENTANE
3-METHYLHEXANE
2,2,4-TRIMETHYLPENTANE
HEPTANE
2,5-DIMETHYLHEXANE
2-METHYLHEPTANE
4-METHYLHEPTANE
3-METHYLHEPTANE
OCTANE
4-METHYLOCTANE
2-METHYLOCTANE
3-METHYLOCTANE
NONANE
DECANE
UNDECANE
DODECANE

CYCLOALKANES

CYCLOPROPANE
CYCLOPENTANE
METHYLCYCLOPENTANE
CYCLOHEXANE
METHYLCYCLOHEXANE
TRANS12DIMETHYLCYCLOHEXANE
PROPYLCYCLOPENTANE
cis-1,2-DIMETHYLCYCLOHEXANE
ETHYLCYCLOHEXANE
tert-BUTYLCYCLOHEXANE
BUTYLCYCLOHEXANE

ALKENES

PROPADIENE
1-BUTENE
1,3-BUTADIENE
3-METHYL-1-BUTENE
1-PENTENE
2-METHYL-1,3-BUTADIENE
TRANS-2-PENTENE
cis-2-PENTENE
2-METHYL-2-BUTENE
4-METHYL-1-PENTENE
3-METHYL-1-PENTENE
1-HEXENE
TRANS-3-HEXENE
1-HEPTENE
TRANS-2-HEPTENE
1-OCTENE
TRANS-4-OCTENE
2-METHYL-1-HEPTENE
2-OCTENE
1-NONENE
1-DECENE

CYCLOALKENES

CYCLOHEXENE
4-METHYLCYCLOHEXENE

ALKYNES

PROPYNE
1-BUTYNE

AROMATICS

BENZENE
TOLUENE
ETHYLBENZENE
M-XYLENE
P-XYLENE
STYRENE
O-XYLENE
ISOPROPYLBENZENE
PROPYLBENZENE
4-ETHYLTOLUENE
3-ETHYLTOLUENE
1,3,5-TRIMETHYLBENZENE
2-ETHYLTOLUENE
tert-BUTYLBENZENE
1,2,4-TRIMETHYLBENZENE
ISOBUTYLBENZENE
sec-BUTYLBENZENE
1,2,3-TRIMETHYLBENZENE
ISOPROPYL-4-METHYLBENZENE
INDAN
1,3-DIETHYLBENZENE
1,4-DIETHYLBENZENE
BUTYLBENZENE
1,2-DIETHYLBENZENE
T-DECALIN
C-DECALIN
1235-TETRAMETHYLBENZENE
1234-TETRAMETHYLBENZENE
1234-TETRAHYDRONAPHALENE
1,4-DIISOPROPYLBENZENE

CHLORINATED AROMATICS

CHLOROBENZENE
2-CHLOROTOLUENE
3-CHLOROTOLUENE
4-CHLOROTOLUENE
1,3-DICHLOROBENZENE
(CHLOROMETHYL) BENZENE
1,2-DICHLOROBENZENE

CHLORINATED ALKANES

CHLOROMETHANE
CHLOROETHANE
DICHLOROMETHANE
2-CHLORO-2-METHYLPROPANE
2-CHLOROBUTANE
TRICHLOROMETHANE
1,2-DICHLOROETHANE
1,1,1-TRICHLOROETHANE
1-CHLOROBUTANE
TETRACHLOROMETHANE
DIBROMOMETHANE
1,2-DICHLOROPROPANE
1-CHLORO-3-METHYLBUTANE
1-CHLOROPENTANE
1,1,2-TRICHLOROETHANE
1,3-DICHLOROPROPANE
1,2-DIBROMOETHANE
1-CHLOROHEXANE
1,4-DICHLOROBUTANE
1,1,2,2-TETRACHLOROETHANE
1,2,3-TRICHLOROPROPANE
1,5-DICHLOROPENTANE
3-(CHLOROMETHYL)HEPTANE

CHLORINATED ALKENES

CHLOROETHENE
3-CHLOROPROPENE
trans-1,2-DICHLOROETHENE
cis-1,2-DICHLOROETHENE
3-CHLORO-2-METHYLPROPENE
2,3-DICHLOROPROPENE
TRICHLOROETHENE
TETRACHLOROETHENE
trans-1,4-DICHLORO-2-BUTENE

COMMON CONTAMINANTS

TOTAL REDUCED SULPHUR COMPOUNDS
SULPHUR DIOXIDE
CARBON MONOXIDE
OXIDES OF NITROGEN (NOx, NO2 AND NO)

UPPER AIR MINISONDE SOUNDINGS

COMMON CONTAMINANTS ctd.

TOTAL HYDROCARBONS (THC, TH-M AND CH4)
OZONE
METEOROLOGICAL : WIND SPEED & DIRECTION
TEMPERATURE
DEW POINT TEMPERATURE
BAROMETRIC PRESSURE
SOLAR RADIATION

TABLE #2

THE INSTRUMENTATION OF MOBILE AIR MONITORING UNIT #1

Instrument	Manufacturer	Analytical Technique	Full Scale Sensitivity
THC, CH4, TH-M analyzer	Ingenieur-Produktions-Gruppe Munchen (IPM) RS-t	Dual flame ionization	50 ppm THC (as CH4)
H2S, SO2, NOx sources	Hartmann & Braun Prufgasgenerator	N/A	N/A
TRS/SO2 analyzer	Monitor Labs 8850 c/w ML 8770	Fluorescence	1.0 ppm SO2 0.5 ppm TRS
NOx, NO2, NO analyzer	Monitor Labs 8840	Chemi-Luminescence	1.0 ppm NOx (as NO2)
CO analyzer	Thermo Electron P48	Gas Filter Correlation	100 ppm CO
O3 analyzer/ source	Dasibi 1003-AAS	UV Absorption	1.0 ppm O3
CO & THC sources	Matheson	Compressed Gas	N/A
Gas Chromatograph	HP 5880 Dual Capillary Column	Flame Ionization Det.	as set per calibrations

Meteorological Instrumentation

Instrument	Manufacturer	Scale
** Wind speed	Lambrecht GmBH	km/hr
** Wind direction	Lambrecht GmBH	degrees
Temperature	Weather Measure (WM) T621	degrees Celsius
Humidity	WM-HM-11P	absolute & %
Barometric pressure	WM-BM70-B242	millibars
Solar Radiation	WM Star Pyranometer	milliwatts/cm2

** These instruments are located on top of a 10 metre retractable tower

Table #3

NIAGARA '86 SURVEY
Monitoring Periods and Site Information - MAMu#1
(Common Contaminant Data)

Monitoring Period**	Start Time	Duration (hrs)	Site ID	Average Winds	COMMENTS
A031	15:59	16.8	A	3303	Overnight & upwd
A042	11:49	4.3	A	0220	Background
A043	16:16	22.0	A	1320	Overnight & upwd
A051	14:57	4.3	C	1510	Niagara Falls
A052	20:22	13.0	A	2202	Overnight & upwd
A062	10:26	2.3	A	2610	Background & upwd
A063	17:18	20.0	A	2001	Overnight & upwd
A071	13:49	2.3	B	0205	DOWNWIND !!
A072	17:25	20.4	A	1606	Overnight & upwd
A081	13:54	47.8	A	2515	Weekend & upwd
N001	15:59	165.8	A	?	All data @ Site A

** in the designation of monitoring periods; 'A' refers to mobile air monitoring unit #1, 'N' refers to a merged data set, 'xx' refers to day of month and 'y' to the data acquisition episode of the day.

Overall average and maximum 30-minute or one-hour average ground level concentrations of Total Hydrocarbons as measured on a continuous basis during the following Monitoring Periods:

A051	2.63 ppm	2.87 ppm (30-min)
A071	2.38 ppm	2.76 ppm (30-min)
N001	1.88 ppm	3.86 ppm (60-min)

TABLE #4

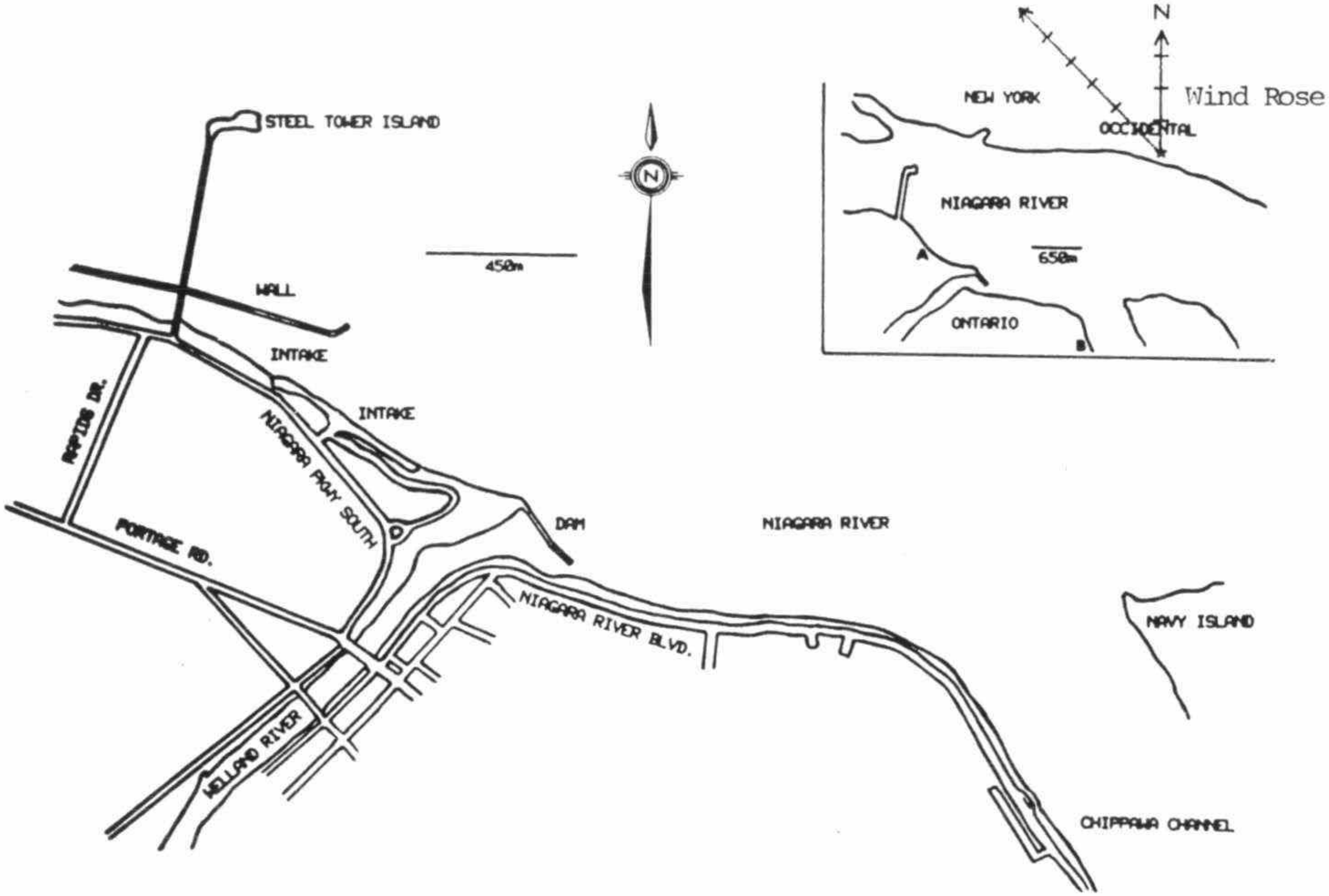
NIAGARA '86 GAS CHROMATOGRAPHIC RESULTS
Data Acquired by Mobile Air Monitoring Unit #1

	Background and Upwind Measurements At Second Intake					Downtown Niagara Falls				Downwind @ #8373 E.Serv.Rd.			Upwind @ 2nd Intake
	NOV 4 15:21	NOV 5 10:49	NOV 5 12:30	NOV 5 14:35	average	NOV 5 15:35	NOV 5 16:39	NOV 5 17:44	average	NOV 7 13:52	NOV 7 14:31	average	NOV 7 12:47
1 PROPANE	4.1	4.7	5.5	3.3	4.4	4.3	8.7	10.1	7.7	20.2	19.6	19.9	25.4
2 CHLOROETHANE	1.2				1.2								1.7
3 2-METHYLPROPANE	1.0	1.4	2.5		1.6	4.2	7.6	7.5	6.4	6.0	6.8	6.4	
4 1-BUTENE							0.7		0.7		1.2	1.2	
5 2CHLORO2METHYLPROPANE						0.9			0.9				
6 BUTANE	0.6	4.9	8.8	7.1	5.3	14.2	29.5	30.9	24.9	30.5	26.7	28.6	22.0
7 2-METHYLBUTANE	1.5	2.5	4.3	3.7	3.0	7.6	15.6	15.0	12.7	10.1	13.0	11.5	7.5
8 PENTANE			2.1		2.1	3.6	8.4	7.4	6.5	5.0	8.0	6.5	4.0
9 TRANS-2-PENTENE							0.9		0.9				
10 2,2-DIMETHYLBUTANE			0.2		0.2		0.6	0.6	0.6				
11 CYCLOPENTANE						0.6	1.3	1.2	1.0				
12 TRANS12DICHOROETHANE						1.7	4.0	3.6	3.1	2.0		2.0	1.5
13 2,3-DIMETHYLBUTANE						0.5	1.0	1.0	0.9				
14 2-METHYLPENTANE						2.1	4.7	4.4	3.7	2.6		2.6	2.1
15 3-METHYLPENTANE						1.5	3.1	2.9	2.5	1.7		1.7	1.3
16 1-HEXENE							0.2		0.2				
17 HEXANE						1.6	4.0	3.1	2.9	1.9	4.6	3.2	1.8
18 METHYLCYCLOPENTANE		0.3			0.3	0.9	1.8	1.7	1.5	0.9	0.4	0.7	0.8
19 1,1,1-TRICHLOROETHANE						3.9	10.6	9.0	7.8	5.7		5.7	5.6
20 BENZENE	0.6				0.6	1.7	3.7	3.7	3.0	2.8	6.1	4.5	2.7
21 CYCLOHEXANE						0.2	0.4	0.6	0.4	0.2	0.6	0.4	0.2
22 2,3-DIMETHYLPENTANE		0.3			0.3	1.0	2.1	2.3	1.8	0.9		0.9	
23 2-METHYLHEXANE		0.4			0.4	1.1	2.4	2.6	2.0	1.0		1.0	
24 3-METHYLHEXANE		0.3			0.3	0.7	1.5	1.6	1.3	0.6	1.6	1.1	0.6
25 2,2,4-TRIMETHYLPENTANE		0.3			0.3	0.7	1.3	1.6	1.2	0.6	1.3	1.0	0.6
26 HEPTANE						0.4	1.0	0.9	0.7		1.2	1.2	0.3
27 METHYLCYCLOHEXANE										0.4		0.4	
28 4-METHYLCYCLOHEXENE								0.2	0.2				
29 2,5-DIMETHYLHEXANE							0.2	0.3	0.2		0.2	0.2	
30 TOLUENE		1.6			1.6	3.6	7.0	7.8	6.2	3.0	9.2	6.1	2.6
31 2-METHYLHEPTANE		0.3			0.3	0.2	0.4	0.5	0.4		0.5	0.5	0.2
32 4-METHYLHEPTANE							0.2	0.3	0.3		0.3	0.3	
33 3-METHYLHEPTANE	0.3	0.4			0.3	0.4	1.0	1.2	0.9	0.3	0.9	0.6	0.5
34 TETRACHLOROETHENE						1.1	1.1	1.0	1.1		1.0	1.0	
35 2-METHYL-1-HEPTENE		0.3			0.3	0.3	0.7	0.7	0.5		0.8	0.8	
36 CHLOROBENZENE	0.9	0.2	0.2	0.4	0.4		0.2		0.2		0.2	0.2	
37 ETHYLBENZENE		0.9			0.9	0.8	2.0	2.0	1.6	0.7	1.9	1.3	0.5
38 M-XYLENE	4.4	4.3		3.6	4.1	2.3	6.5	6.0	5.0	3.3	6.6	5.0	1.4
39 4-METHYLOCTANE		0.2			0.2	0.1	0.3	0.5	0.3		0.4	0.4	
40 2-METHYLOCTANE											0.3	0.3	
41 STYRENE											0.3	0.3	
42 O-XYLENE	2.1	1.7		1.6	1.8	0.9	2.5	2.2	1.9	1.4	2.8	2.1	0.6
43 NONANE		0.3			0.3	0.3	0.8	0.5	0.5		0.8	0.8	
44 ISOPROPYLBENZENE											0.5	0.5	
45 N-PROPYLBENZENE	0.2	0.3			0.2								
46 4-CHLOROTOLUENE	0.1	0.3			0.2		0.5	0.4	0.5		0.7	0.7	
47 3-ETHYLTOLUENE	0.8	1.1		0.7	0.9								0.4
48 4-ETHYLTOLUENE						0.5	0.7	0.6	0.6		1.6	1.6	
49 1,3,5-TRIMETHYLBENZENE	0.6	0.6		0.6	0.6								
50 2-ETHYLTOLUENE	0.4	0.5		0.4	0.4								
51 1,2,4-TRIMETHYLBENZENE						1.2	3.0	2.9	2.4	1.1	7.9	4.5	
52 tert-BUTYLBENZENE						1.6	4.0	3.8	3.1	1.4	11.1	6.2	0.7
53 DECANE						0.3	1.3	0.8	0.8		0.8	0.8	0.3
54 1,2,3-TRIMETHYLBENZENE	0.3	0.4	0.1		0.3								
55 INDAN		0.3		0.3	0.3		0.4	0.3	0.3		0.6	0.6	
56 UNDECANE	0.6		0.6		0.6	0.6	1.7	1.5	1.3		0.6	0.6	3.0
57 1235-TETRAMETHYLBENZENE							0.5	0.6	0.6		0.5	0.5	
58 DODECANE								0.5	0.5				0.4
Total Compounds Identified	19	30	11	15	18.8	40	48	45	44	29	38	34	30
Total Hydrocarbons ug/m3	19.7	28.6	24.4	21.5	23.5	67.6	150.2	146.0	121.2	104.4	141.3	122.8	86.6
Alkanes ug/m3	8.1	16.2	24.0	14.0	15.6	45.6	97.9	97.9	80.5	81.4	87.8	84.6	69.9
Cycloalkanes ug/m3	0.0	0.3	0.0	0.0	0.1	1.6	3.5	3.5	2.9	1.6	1.0	1.3	1.0
Alkenes ug/m3	0.0	0.3	0.0	0.0	0.1	0.3	2.4	0.7	1.1	0.0	2.0	1.0	0.0
Cycloalkenes ug/m3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0
Alkynes ug/m3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aromatics ug/m3	9.4	11.6	0.1	7.1	7.1	12.7	30.4	29.8	24.3	13.7	49.0	31.3	8.9
Chlorinated alkanes ug/m3	1.2	0.0	0.0	0.0	0.3	4.8	10.6	9.0	8.2	5.7	0.0	2.9	7.3
Chlorinated alkenes ug/m3	0.0	0.0	0.0	0.0	0.0	2.8	5.1	4.7	4.2	2.0	1.0	1.5	1.5
Chlorinated aromatics ug/m3	1.0	0.5	0.2	0.4	0.5	0.0	0.7	0.4	0.4	0.0	0.9	0.4	0.0

NIAGARA_86: A051

Start: 86/11/05 14:56 Scan: 60 sec. Ave: 30.0 min. Duration: 4.3 hrs.
Loc: Niagara Central Arena on Kitchner Street..UTM 563-729

WINDS Blowing Towards
1 Division = 10% of Time
Calm (< 3 km/hr) = .0%
Low (< 3 km/hr) = .0%
High (>100 km/hr) = .0%



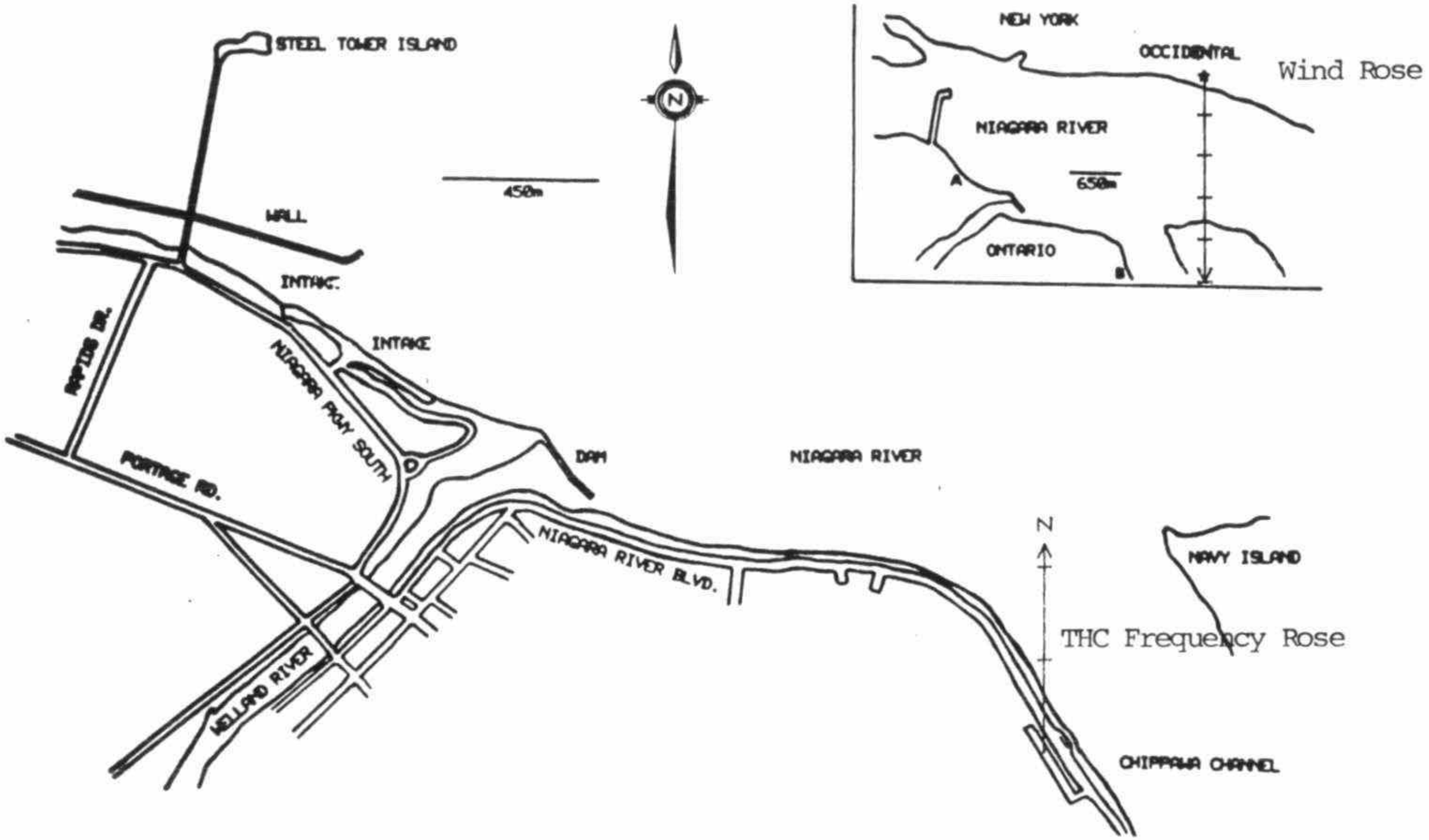
PLOT #1

NIAGARA_86: A071

Start: 86/11/07 13:48 Scan: 60 sec. Ave: 60.0 min. Duration: 2.3 hrs.
Loc: @ #8373 East Service Road...downwind Niagara (USA) Indus. Complex

WINDS Blowing Towards
1 Division = 10% of Time
Calm (< 3 km/hr) = 50.0%
Low (< 3 km/hr) = .0%
High (>100 km/hr) = .0%

THC Blowing From
1 Division = 1 ppm -- A. MEAN



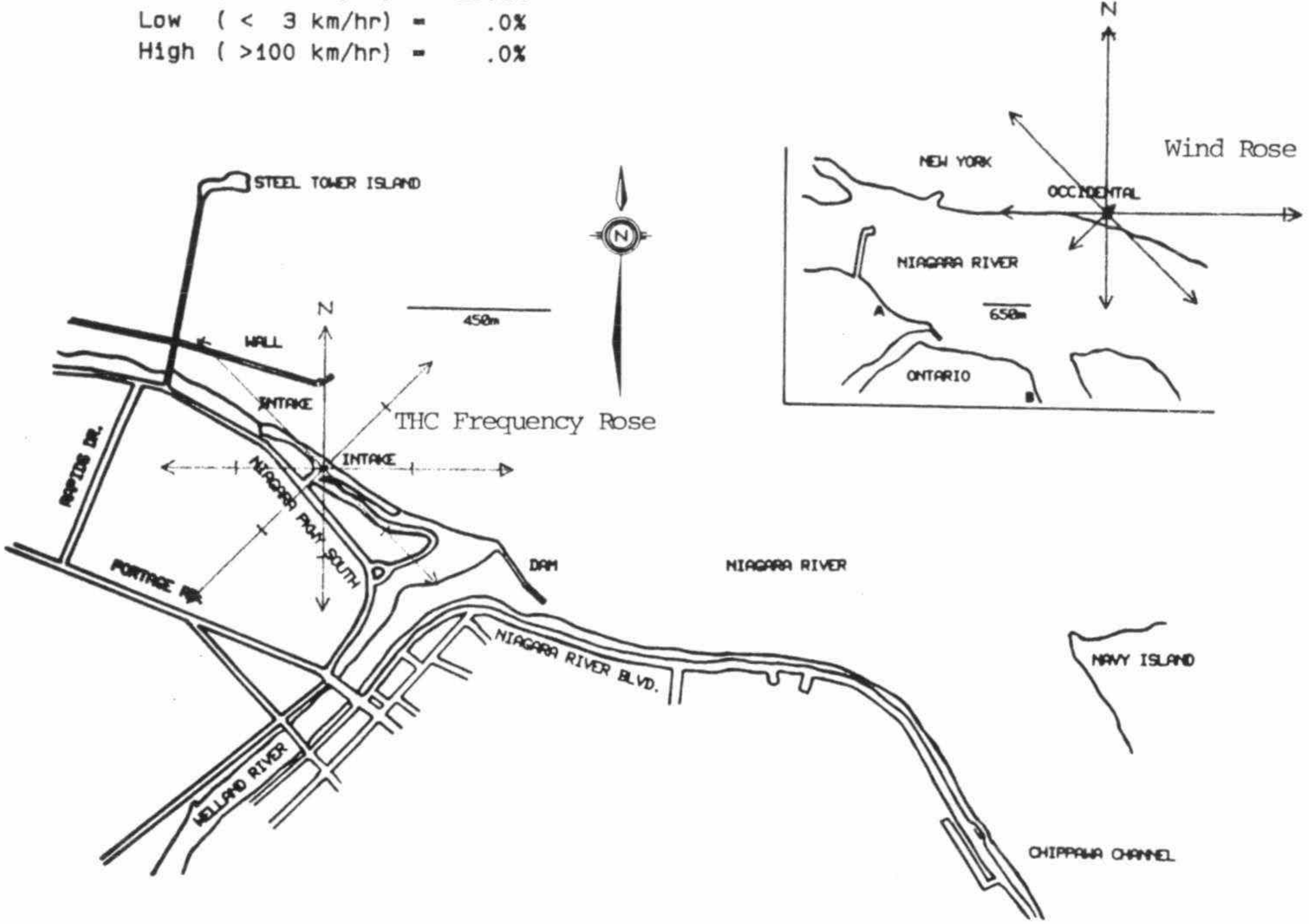
PLOT #2

NIAGARA_86: N001

Start: 86/11/03 15:54 Scan: 300 sec. Ave: 60.0 min. Duration: 165.8 hrs.
Loc: Merged data set for all data acquired at 2nd Intake

WINDS Blowing Towards
1 Division = 10% of Time
Calm (< 3 km/hr) = 33.9%
Low (< 3 km/hr) = .0%
High (>100 km/hr) = .0%

THC Blowing From
1 Division = 1 ppm -- A. MEAN

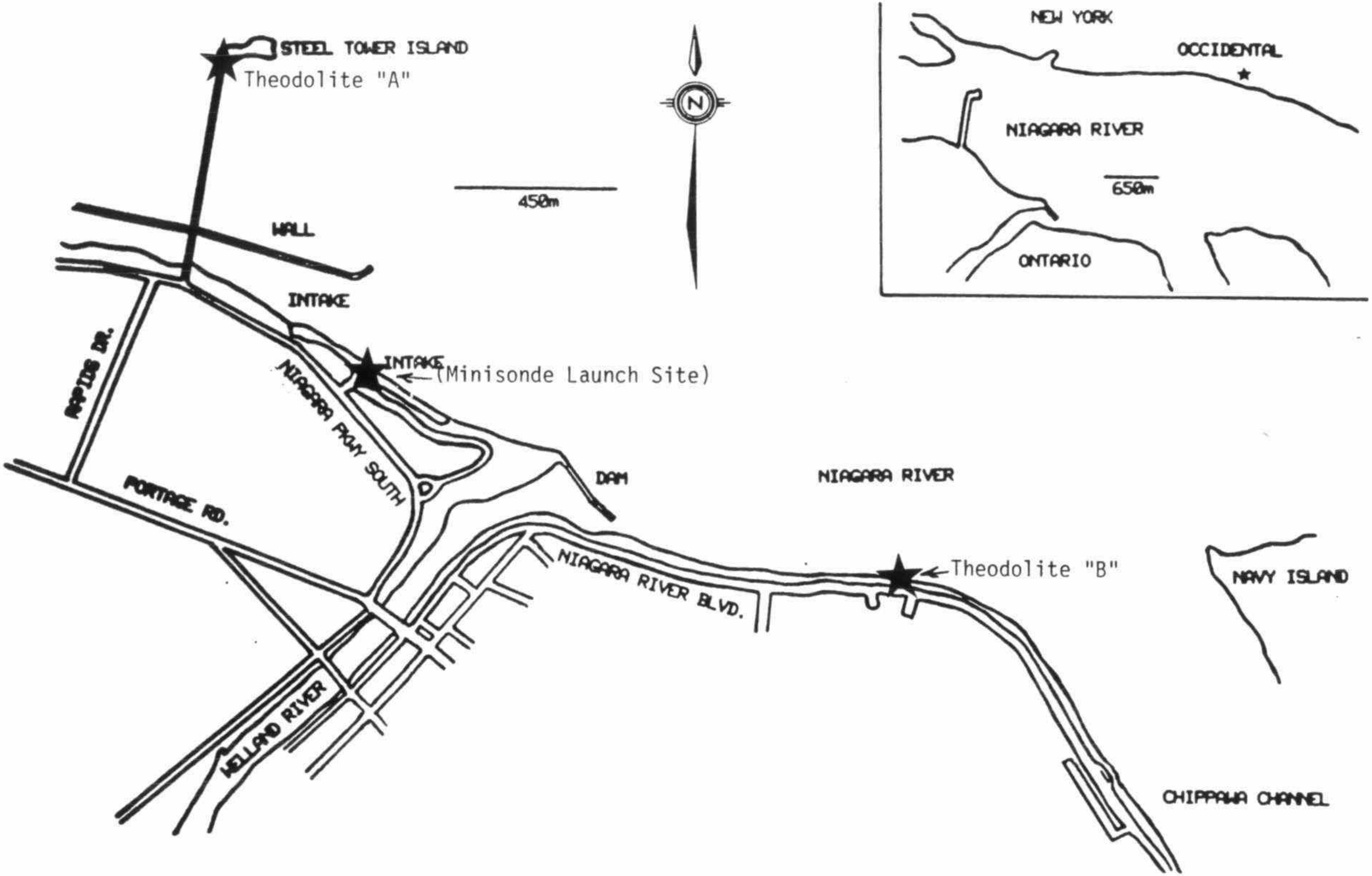


PLOT #3

APPENDIX D

UPPER-AIR MINISONDE RESULTS

Theodoloite and Minisonde Launch Sites

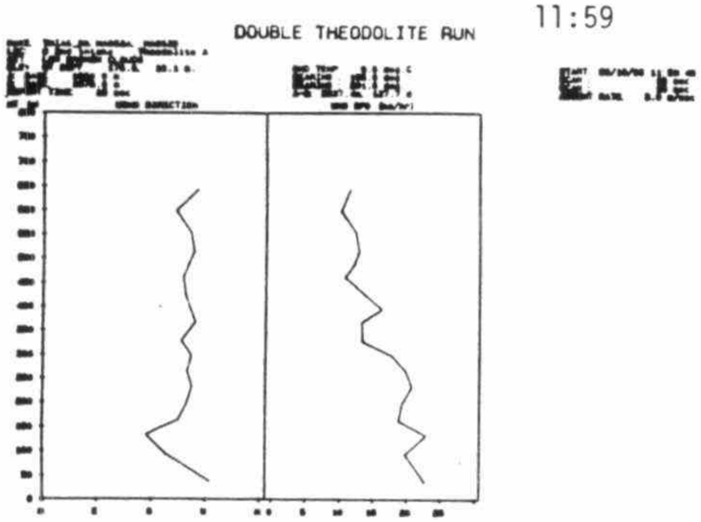


UPPER AIR MINISONDE SOUNDINGS

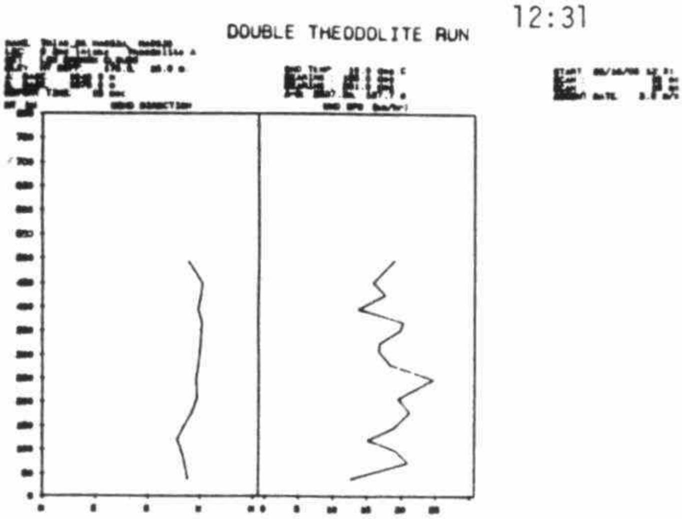
Niagara Falls '86

November 6

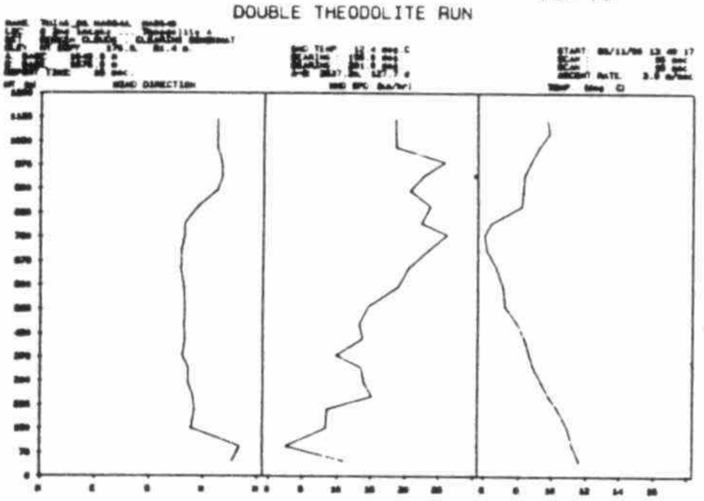
11:59



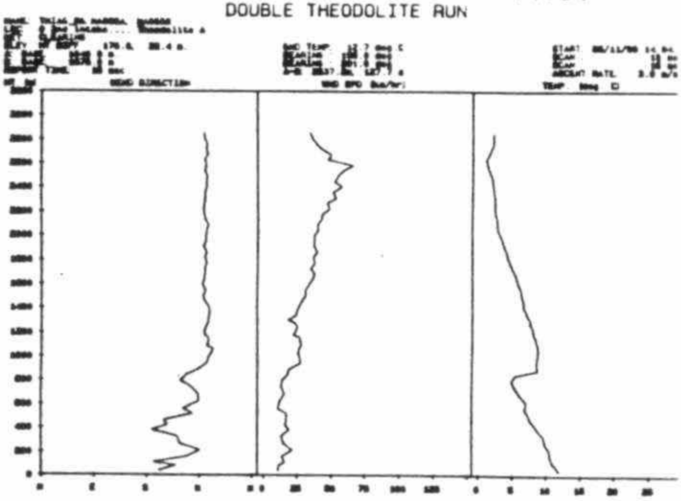
12:31



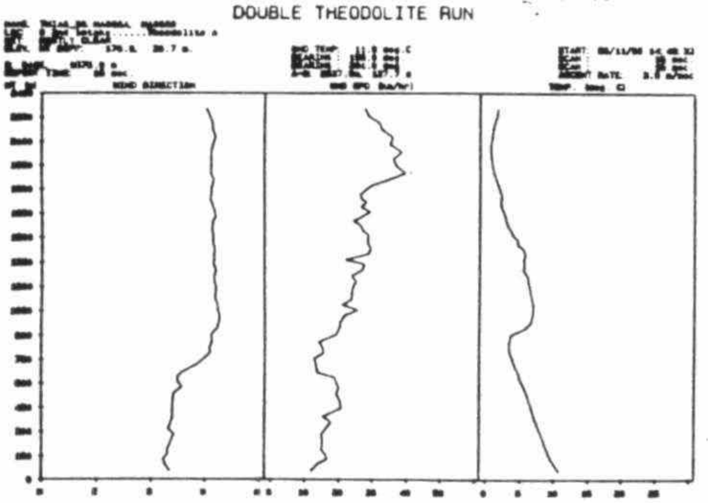
13:40



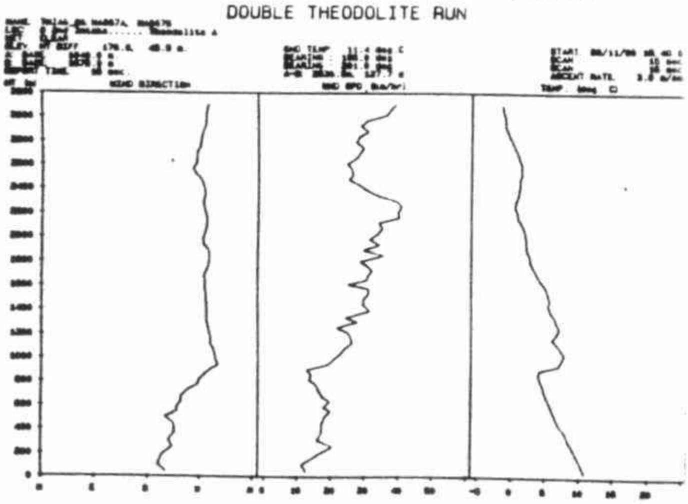
14:04



14:49



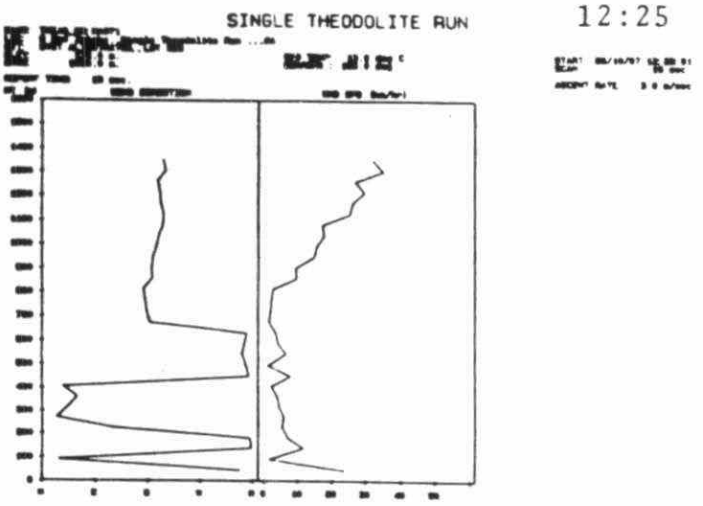
15:40



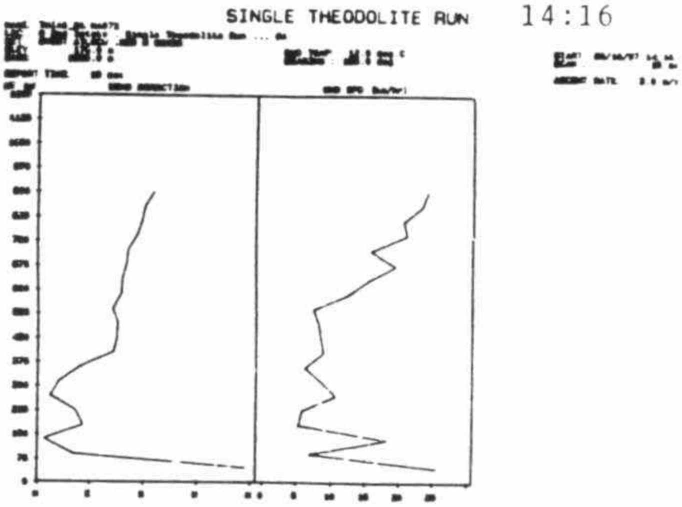
UPPER AIR MINISONDE SOUNDINGS

Niagara Falls '86

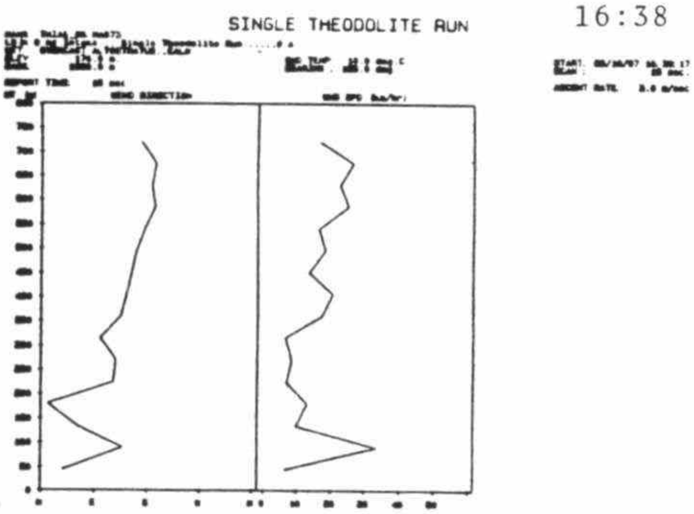
November 7



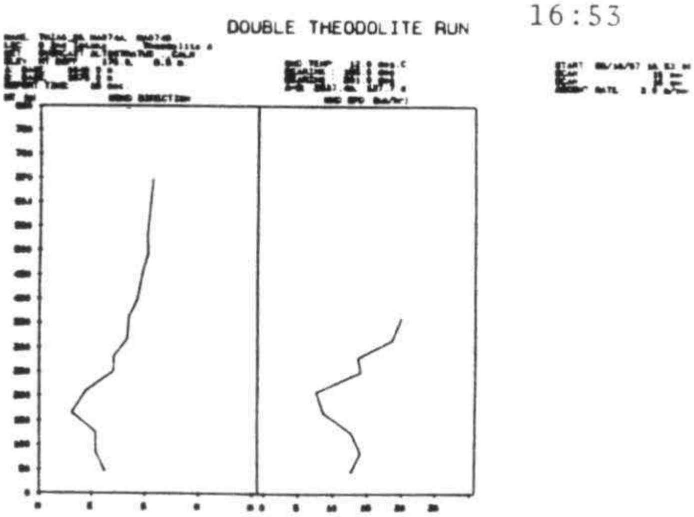
12:25



14:16



16:38



16:53

TD
883
A.
N54
198